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REPORT No. 5/65

Frequency Assignment to Radio Relay Area Communication Systems in the Forward Combat Zone of an Army Group

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DEFENCE OPERATIONAL ANALYSIS ESTABLISHMENT

REPORT No. 5/65

7 ~~FREQUENCY ASSIGNMENT TO RADIO RELAY AREA~~
~~COMMUNICATION SYSTEMS IN THE FORWARD~~
~~COMBAT ZONE OF AN ARMY GROUP~~ [S], 8

10 B.W. Purslow,
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FOREWORD

This report of a DOAE study of frequency assignment to radio relay area communication systems is unusually detailed, but this presentation has been adopted for the following reasons:

a. It is hoped, by giving a detailed account of the approach to the study and of its evolutionary development, to provide the fullest possible understanding of the frequency assignment problem and its solution.

b. To obviate possible duplication of the DOAE effort by including a description of the methods explored which failed to meet the aim of the study.

c. To present a useful background against which the merits of any new methods of frequency assignment may be assessed.

FREQUENCY ASSIGNMENT TO RADIO RELAY AREA COMMUNICATION SYSTEMS IN THE FORWARD COMBAT ZONE OF AN ARMY GROUP

by

B.W. Purslow

Lt. Col. K.S. Newell, R. Signals

SUMMARY

Most NATO countries are considering ~~the use of~~ radio relay area communication systems for deployment in Europe in the 1970-80 era~~, but are unwilling to procure equipment before being assured~~ that sufficient frequencies will be available. SHAPE ~~therefore~~ requested the UK to study the problems of operating a large number of radio relay links in the Forward Combat Zone of an Army Group without excessive interference~~, and to recommend a suitable method of frequency assignment~~. The UK plan for an area communication system, ALLERTON, which is part of the HOBART plan, was to be taken as a basis for the study. ALLERTON is planned to operate in the frequency band 225-960 Mc/s, in which band the majority of area communication systems are ~~also~~ being designed.

Methods of ~~This paper describes the way in which~~ deployments of area communication systems of the ALLERTON type ~~were planned~~ in each of ~~the corps areas of NORTHAG~~ *. It gives the results achieved by applying various manual methods of frequency assignment to the corps area systems, using only those frequencies presently allocated to NORTHAG for military mobile radio relay use in war. These total 369 frequencies, 57 of which are in the 225-400 Mc/s band, 216 in the 622-790 Mc/s band and 96 in the 790-960 Mc/s band. None of these methods was found to be entirely satisfactory. Finally a method was evolved, called the Modified A-B-M Plan, which appears to make possible the assignment of frequencies, not only to corps in NORTHAG, but to all corps in Europe, without excessive interference and within the frequencies currently allotted for use in war. It is extremely simple and quick to operate, assures compatibility of frequencies and affords a degree of flexibility which matches the mobile nature of the communication systems concerned. This method involves arranging available frequencies into two groups for allocation to alternate corps, thus giving each corps absolute control of frequency assignment within its area and ~~also~~ a choice of method of assignment.

* are discussed.

It is recommended that:

a. The results of this study are communicated to the national authorities and NATO Headquarters concerned, noting that, in the planning of area communication systems, satisfactory operation will be possible within the frequencies currently available to the military in war provided that unanimous agreement is given to the allocation of frequency lists, similar to A and B used in this study, to all corps in Central Europe, irrespective of the method of frequency assignment to be used within each corps. If this recommended allocation of frequencies is implemented, the Modified A-B-M Plan should be adopted as the standard manual method of assigning frequencies to corps area communication systems: if it is not implemented, it is impracticable for any corps, unilaterally, to use the Modified A-B-M Plan or any other plan as envisaged in this study.

b. Steps are taken by SHAPE to secure at least 24 additional frequencies, as many as possible in the 225-400 Mc/s band, so that all Formation HQ links can be assigned frequencies separate from the trunk link assignments.

c. Nations concerned should develop or use equipment whose spectrum signature is at least as "clean" as that predicted for AN/GRC-103.

d. Trials on the ground are carried out as soon as possible to reduce the uncertainty regarding the minimum distance at which co-channel repetition of frequencies is possible.

CONTENTS

FREQUENCY ASSIGNMENT TO RADIO RELAY AREA COMMUNICATION SYSTEMS IN THE FORWARD COMBAT ZONE OF AN ARMY GROUP

by

B.W. Purslow

Lt.Col. K.S. Newell, R Signals

INTRODUCTION

Background

1. Most of the member nations of NATO whose military forces are deployed in Central Europe are considering the requirement for radio relay area communication systems for use by their respective forces in the 1970-80 era, but are unwilling to procure equipment until they are satisfied that sufficient frequencies will be available.

2. The majority of area communication systems are currently being designed to operate in the frequency band 225-960 Mc/s. The number of frequencies available in this band in Central Europe is extremely limited in relation to the likely requirement for radio relay links, and interest has been expressed in the problems of operating area communication systems, particularly in the Forward Combat Zone, without excessive interference.

3. For this reason, SHAPE requested the UK Ministry of Defence, whose plans for an area radio relay communication system are comparatively well advanced, to study the problems of frequency assignment to area communication systems in Central Europe. This request was passed by SO-in-C(A) to the Defence Operational Analysis Establishment (then the Army Operational Research Establishment) with the specific task of finding an acceptable method of assigning frequencies, on an Army Group basis, to area communication systems in the Forward Combat Zone.

4. The problems had been well defined in a previous AORE study, described in an AORE Report(1) which also contains detailed information on frequency availability and usage in the bands concerned. This Report has greatly assisted in the study of frequency assignment methods.

Aim

5. The aim of the study covered by the present report was to find a suitable manual method of assigning frequencies, on an Army Group basis, to radio relay area communication systems in the Forward Combat Zone.

METHOD

Assumptions

6. It was necessary to make a number of assumptions on which to base the study. These were:

a. Area communication systems used in all corps areas would be similar in concept to the ALLERTON (HOBART) System, which is outlined in School of Signals Planning Wing Study No. 27[2].

b. Radio relay sets would operate on low power, of the order of 25 watts RF output, and have similar characteristics to the Canadian Marconi equipment AN/GRC-103; in particular, a bandwidth requirement of 0.5 Mc/s for each single way transmission.

c. Only those frequencies presently allocated to NORTHAG for military mobile radio relay use in war would be available. These total 369 frequencies; 57 of which are in the 225-400 Mc/s band, 216 in the 622-790 Mc/s, and 96 in the 790-960 Mc/s band.

d. Some re-use of frequencies (frequency repetition) would be inevitable because of the limited number of frequencies available in relation to the requirement. In this paper frequency repetition distance denotes the length of an interfering signal path where the interfering and wanted signals are at the same frequency.

e. A frequency assignment plan for area communication systems must provide for considerable movement, expansion and reconfiguration of networks at short notice.

Area of Study

7. The NORTHAG area was selected for detailed study because information on formation boundaries and organisation was readily accessible, and also because it made possible the relation of the frequency assignment study to studies of other aspects of an area communication system in the present 1(BR) Corps area which have been undertaken at this Establishment.

Deployments of Corps Within NORTHAG

8. Realistic deployments of area communication systems are fundamental to a frequency assignment study. In the British Corps area, a measure of realism was provided by the war game technique which had been used to simulate a Force deployment in a tactical setting in the time frame 1968-73. A study was made of an area communication system deployment which seemed likely to satisfy the communication requirements of this Force, as reported in DOAE Research Memorandum No. 1/65[3]. This deployment, together with subsequent tactical redeployments, was used as the basis of the frequency assignment study in the British Corps area.

9. In each of the other corps areas not represented in war game studies, Formation HQ were tactically sited on the map and then, from map study of the ground to determine possible radio relay

paths, an area communication system was developed to support the Formation HQ deployment.

Technical Considerations

10. Detailed radio relay frequency compatibility rules[4] were evolved, based on the predicted technical characteristics of the AN/GRC-103. These rules take into consideration the various conditions which are likely to apply in a typical communication centre (nodal point) layout; for example, the spacing of vehicles, the installation of two stations in one vehicle, and the use of separate transmit and receive aerials on the same mast.

11. A summary of the rules governing the frequency separations to be observed is given below:

a. Receiver to Receiver Separation

At a nodal point in the communication system and at a Formation HQ, receiver frequencies shall be spaced not less than 1 Mc/s apart and shall not be spaced by 30 Mc/s (which is the intermediate frequency of AN/GRC-103).

b. Transmitter to Transmitter Separation

(1) At a nodal point, transmitter frequencies shall be spaced not less than 0.5 Mc/s and shall not be spaced by 30 Mc/s.

(2) At a Formation HQ, transmitter frequencies shall be spaced not less than 1 Mc/s apart and shall not be spaced by 30 Mc/s.

c. Transmitter to Receiver Separation

(1) At a nodal point or a Formation HQ the minimum spacing shall be:

For antennae on the same mast	–	10 Mc/s
For antennae on masts separated by a vehicle length	–	8 Mc/s
For antennae on separate vehicles spaced $\frac{1}{4}$ mile apart	–	3 Mc/s

(2) For antennae on the same mast, T-R spacing shall not be $\pm$ 30 or $\pm$ 60 Mc/s in any band or $\pm$ 15 Mc/s in Band I. Avoid R values of 2T/3, 3T/2 and 4T/3 in Band I only.

(3) For antennae on masts separated by a vehicle length, as for (2) above but for positive T-R values only.

12. If the above rules are obeyed, intermodulation products place no additional restrictions on the assignment of frequencies. The simplicity of these rules results from the comparatively "clean" spectrum signature predicted for AN/GRC-103; a less "clean" equipment would require more complicated rules and so magnify the problem of frequency assignment.

13. If frequencies are so assigned that any arrangement or subsequent re-arrangement of links at nodal points is possible without jeopardizing compatibility, flexibility in the layout of nodal points is greatly enhanced. This can be achieved if the assignment method provides for a minimum transmitter-receiver separation of 10 Mc/s for all transmitters and receivers at nodal points (thus meeting the most stringent rule for antennae on the same mast).

Methods of Frequency Assignment

14. All known manual methods of frequency assignment were considered but detailed study was confined to those methods, and modifications thereto, which appeared to offer the degree of flexibility and simplicity of operation necessary for the type of communication system being considered. It is thought best to describe all the methods studied (not simply the one which offers the best results) in order to provide the fullest possible understanding of the problem and its solution, and also to obviate the need for repetition of the studies elsewhere. The methods described are:

a. The Six-Way Linear Lattice Method (rejected).

b. The Quadrant Plan (failed as an Army Group plan).

c. The Modified Quadrant Plan (a possible solution but inferior to d.).

d. The Modified A-B-M Plan (the recommended solution).

THE SIX-WAY LINEAR LATTICE METHOD

15. The Six-Way Linear Lattice method was proposed in a previous AORE Report(1) as a possible solution to the frequency assignment problem. A brief description of this form of lattice and its method of application to frequency assignment is given at Annex 'A'.

16. At first sight the method is particularly attractive because it provides for six links in three vehicles at nodal points which corresponds to the number and arrangement of links planned for an ALLERTON (HOBART) communication centre. After closer examination, however, the method was rejected as being too rigid. Specifically it has the following major disadvantages:

a. Excess distortion of the lattice is necessary for the typical corps system, the nodal points of which are unevenly distributed geographically. As a result, no reliance can be placed on direction in determining "safe" frequency repetition distances which must therefore be planned on the basis of interfering signal paths of the worst type and which in consequence, are excessive.

b. It provides only for links to adjacent nodal points whereas in practice it is often necessary to cross-link nodal points which are not adjacent, particularly after a system has sustained damage.

c. The fixed geometry of the lattice is not conducive to tactical flexibility. The move of a single nodal point often necessitates a frequency change at a number of other nodal points not otherwise involved in a redeployment. The same difficulty arises when new nodal points are established within the perimeter of an existing communication system.

THE QUADRANT PLAN

General

17. An outline description of the Quadrant Plan and its method of application are given at Annex "B".

18. This plan is of United States origin. It is an extremely versatile method of frequency assignment, is well designed and relatively simple to operate. As it stands, it cannot be applied to achieve the aim of this study, but it is capable of adaptation so that it provides a reasonable solution.

Aim of the Plan

19. The Quadrant Plan has three main objectives:

a. To assure compatibility of frequencies at every nodal point in a communication system. The A-B-M method incorporated in the plan sets the minimum frequency separation between transmitters and receivers at a nodal point, and the quadrant itself fixes the frequency separation between receivers.

b. To assure adequate distance between assignments involving repetition.

c. To permit decentralised assignment of frequencies without the need for extensive co-ordination or rigid central control.

Application of the Plan and Results Achieved

20. An assignment of frequencies was made in turn to the communication systems, including Formation HQ links, already deployed in each corps area (vide Paragraphs 8 and 9). In the case of the British Corps area, re-assignment of frequencies was also made to the modified communication system resulting from a redeployment of a number of the corps formations. The results were as follows:

a. Frequency Separation

The transmitter-receiver and receiver-receiver frequency separations required by the rules were fully met at each nodal point except that:

(1) There was an average of one case of 30 Mc/s and one of 60 Mc/s undesirable separation in each corps system, but only in one case in all the assignments did this involve radio terminals in the same vehicle, which is the worst case.

(2) There were a few cases of two transmitters at one nodal point being assigned the same frequency; otherwise the transmitter-transmitter separation was one channel number or more.

b. Frequency Repetition

In an ideal system layout having one nodal point in each quadrant square and with the letters A, B and M ideally assigned, the frequency repetition distance is fixed at about 80 km, using 10-km squares. Unfortunately, in the system layouts being considered, which are of non-uniform pattern, the frequency repetition distance is random and was found to be as little as 10 km, using 10-km squares. This distance may suffice for some link configurations but is thought to be inadequate for general planning purposes. However, provided there is a central frequency assigner, various means of avoiding close and unintelligent repetition of frequencies can be used. These are:

(1) Assigning approximately equal numbers of letters A, B and M to nodal points.

(2) Assigning frequencies systematically, starting with nodal points at the front end of the operational area and working towards the rear.

(3) The use of frequencies listed for unused directions of reception in the quadrant square associated with the nodal point.

(4) Assigning frequencies to all links at a nodal point as if it were located in one of the adjacent squares.

(5) The use of spare frequencies.

Using these means, it was found possible, in all initial deployments, to avoid re-using frequencies at less than 60 km separation and also to reduce the incidence of repetition. Note, however, that minimum frequency repetition distances are directly related to the size of the quadrant square. A 10-km square was found to be about right for the 15-km average link length of the networks considered and was used in all frequency assignments. A larger size would have resulted in more than the permissible maximum of three nodal points in one square while a smaller size would have further reduced the frequency repetition distance.

c. Redeployments

When frequencies are assigned by a central assigner, movement of a Formation HQ or a nodal point entails redrawing to scale the affected part of the communication network, recovering the frequencies no longer in use and assigning new frequencies to the reconstituted portion of the network. When frequency assignment was associated with a war game, it was found that movement, particularly of Formation HQ, was so frequent or on such a scale that the frequency assigner had the greatest difficulty in

satisfying all frequency requirements within a reasonable time, even though he was only concerned with the communication system of a single corps.

Redeployment sometimes resulted in nodal points having the same letter A, B or M being linked together; the only recourse was to assign spare frequencies to both ends of such links.

d. Cross-Linking

When a communication system has suffered extensive damage, it is necessary to interconnect undamaged nodal points, using spare equipment. It was found that in some cases two nodal points having the same letter A, B or M were interconnected. Again this problem can be overcome by assigning spare frequencies to both ends of such links or, if justified by the extent of network changes, by re-assigning the letters A, B and M to the whole or part of the network and re-assigning frequencies correspondingly.

e. Expansion of Communication Systems

It is sometimes necessary to add nodal points to corps communication systems due, for example, to an advance or withdrawal, an extension of the corps area, or the addition of new formations to the Order of Battle. Outward expansion of the communication system presented no problem. However, in the case of additions which increased the density of nodal points in the centre of an existing system, distances were too short to permit safe repetition of frequencies in use and at this stage few others except spares were available. If insufficient spare frequencies are available, it is necessary to assign new letters and frequencies to a part of the system, involving a change of frequencies for some existing links.

f. Assignment Time

After drawing the communication system diagram to scale, assigning the letters A, B and M to nodal points, and preparing the frequency list, it took 3½-4 hours to make an initial assignment of frequencies to each of the corps systems. The time taken to re-assign frequencies as a result of war game redeployments varied between 10 minutes and 1½ hours, including essential preparations. It is conceivable that a redeployment on a large scale might involve re-assignment of frequencies to the whole of a communication system, in which case the time required would be 1 hour for preparation plus 3½-4 hours for the assignment.

21. **Summary of Results**

a. The frequency compatibility rules were broadly met.

b. Frequency repetition distances were too short except when controlled by a central assigner.

c. The redeployments of Formation HQ were so frequent that a central assigner, even at corps level, would have had difficulty in satisfying all frequency demands with acceptable delay.

d. Cross-linking of nodal points and expansion of networks presented only minor problems which were readily solved.

e. The time required for frequency assignment to a corps system was:

$3\frac{1}{2}$-4 hours for an initial deployment.

Up to $1\frac{1}{2}$ hours for subsequent redeployments, but this could be very much longer for major redeployments.

<u>Discussion of Results and Development of the Study</u>

22. So far the Quadrant Plan method of frequency assignment had been applied only to corps communication systems on an individual corps basis.

23. Consideration was next given to applying the Plan to corps communication systems on an Army Group basis. It was found that two of the results had conflicting implications and combined to pose an insoluble problem:

a. Central assignment at Army Group is essential to avoid mutual interference which would result from the random repetition of frequencies at too-short distances (vide Paragraph 20 b).

b. Central assignment at Army Group is precluded by the time delay in assigning frequencies to meet the frequent demands of redeployment (vide Paragraph 20 c). It is doubtful if central assignment, even at corps level, is feasible when movement is rapid.

24. Further study showed that the problem could be evaded if:

a. Adjacent corps systems are assigned frequencies from separate frequency lists and control of assignment is vested in corps HQ. This is consistent with corps having control over all other aspects of their respective communication systems.

b. Formation HQ links, particularly those most subject to frequent moves, are assigned frequencies separate from the Quadrant Plan.

25. For this to be possible, the following frequencies would be required:

a. 2 x 144 = 288 Quadrant Plan frequencies for assignment to trunk links.

b. 2 x 68 = 136 Formation HQ link frequencies (68 frequencies are sufficient for up to 17 HQ, each with a working link to one nodal point and an alternate link to another).

This makes a total of 424 frequencies, excluding spares, whereas only 369 are available (vide Paragraph 6 c).

26. The Quadrant Plan was then modified to use 96 frequencies instead of 144 which reduced the frequency requirement to:

a. 2 x 96 = 192 Quadrant Plan frequencies.

b. 2 x 68 = 136 Formation HQ link frequencies.

This makes a total of 328 frequencies, leaving 41 for use as spares.

27. Details of the Modified Quadrant Plan and the method of grouping frequencies to provide separate lists for adjacent corps and for Formation HQ links are given in the following section.

THE MODIFIED QUADRANT PLAN AND FREQUENCY GROUPING

The Modified Quadrant Plan

28. A description of the Modified Quadrant Plan and the method of applying it to frequency assignment are given at Annex "C".

29. The main differences between the 96-frequency and 144-frequency Quadrant Plans, assuming both are applied by a central frequency assigner, are:

a. The minimum transmitter-receiver frequency separation at nodal points is 16 channel numbers instead of 24.

b. The minimum receiver-receiver frequency separation at nodal points is 4 channel numbers instead of 6.

30. The transmitter-receiver frequency separation is insufficient to satisfy the compatibility rules if the channels are contiguous at 0.5 Mc/s spacing, but if the channels are spaced at least 1 Mc/s apart, the rules can be adequately met.

Frequency Grouping

31. The frequencies available in war were divided into four groups, as shown in Table I, and within each group the frequencies, in rising

TABLE I

GROUPING OF FREQUENCIES

Group	Frequency Band	Use	Total Frequencies
I	235.5 - 399.5 Mc/s and 622.5 - 684 Mc/s	Formation HQ Links List A (69 frequencies) List B (68 frequencies)	137
II	684.5 - 701 Mc/s	Spares for Trunk Links List A (10 frequencies) List B (10 frequencies)	20
III	701.5 - 908 Mc/s	Trunk Links (Quadrant Plan) List A (96 frequencies) List B (96 frequencies)	192
IV	908.5 - 923 Mc/s	Spares for Trunk Links List A (10 frequencies) List B (10 frequencies)	20

order, were allotted alternately to a List "A" and List "B". This arrangement provided:

a. Separate frequencies for Formation HQ links.

b. Separate frequency lists for adjacent corps for both Formation HQ and Trunk links.

c. Channel spacing of at least 1 Mc/s within each list.

32. The resulting Frequency Lists A and B are reproduced in detail in Tables II and III.

33. List A was then allotted to 1(NL) Corps and 1(BR) Corps, and List B to 1(GE) Corps and 1(BE) Corps.

<u>Features of Plan</u>

34. The Modified Quadrant Plan, used in conjunction with the method of frequency grouping described above, introduces the following features:

a. The lowest frequencies are made available to Formation HQ links, the terminals of which are often tactically sited to the detriment of good communication at higher frequencies.

b. Formation HQ are able to move freely within the trunk system and to link into and be generally compatible with any nodal point. This is because Formation HQ link frequencies are separated from trunk frequencies by more than the 10 Mc/s required by the frequency compatibility rules.

c. The effects of redeployments on frequency assignment are greatly reduced as the central frequency assigner is now concerned only with moves of nodal points in the main trunk system (plus possibly one or two of the Formation HQ which are least subject to frequent moves, as will be explained later).

d. The spacing between adjacent frequencies on each list is at least 1 Mc/s which enables all the main frequency separation rules to be met comfortably and also reduces the risk of adjacent channel interference from and to neighbouring nodal points.

e. Formation HQ link frequencies are drawn from two widely separated bands between which pairing of frequencies will not normally be practicable as separate radio frequency heads are likely to be required for each band. However, it is possible to pair frequencies within each band.

f. The repetition of frequencies laterally across the Army Group front is precluded at less than the width of adjacent corps. The width of corps areas averages 60 km, but in practice nodal points are normally sited well inside flank corps boundaries which effectively increases the repetition distance to about 80 km. Additionally, links from peripheral nodal points are mainly directed inwards to the centre of corps areas which reduces still further the likelihood of mutual interference between corps using the same frequency lists. The repetition of frequencies within each corps area is controlled by the corps central frequency assigner.

TABLE II

LIST "A" FREQUENCIES
(allotted to 1(NL) Corps and 1(BR) Corps)

Formation HQ Links		Trunk Links			Spares
235.5	632	701.5	755.5	848.5	684.5
237.5	633	703	758	849.5	686.5
239.5	634.5	704.5	760	850.5	688
241.5	636.5	705.5	761	851.5	690
245.5	638	706.5	763.5	852.5	692
247.5	639.5	707.5	765	853.5	693
249.5	640.5	708.5	767	854.5	696.5
265.5	642	710	768.5	855.5	697.5
281.5	644	712	770.5	858	699
286.5	645.5	713.5	772	859	700.5
290.5	646.5	714.5	774	860	
298.5	648	716	776	861	908.5
300.5	649	717	777	873.5	909.5
306.5	650.5	718.5	780.5	874.5	912
314.5	652	720.5	781.5	875.5	916.5
322.5	653.5	722	783	876.5	917.5
346.5	655.5	723.5	784.5	902.5	918.5
366.5	657	724.5	785.5	903.5	919.5
369.5	658.5	726	787	904.5	920.5
372.5	660	728	788.5	905.5	921.5
374.5	661.5	729.5	789.5	906.5	922.5
377.5	663.5	730.5	790.5	907.5	
382.5	665	732	791.5		
387.5	666.5	733	792.5		
389.5	668	734.5	793.5		
392.5	669.5	736	794.5		
395.5	671.5	737.5	795.5		
397.5	674	739.5	796.5		
399.5	676	741	797.5		
	677	742.5	800		
622.5	679.5	744	801		
623.5	681	745.5	802		
624.5	683	747.5	803		
626		749	804		
628		750.5	805		
629.5		752	806		
630.5		753.5	807		

TABLE III

LIST "B" FREQUENCIES
(allotted to 1(GE) Corps and 1(BE) Corps)

Formation HQ Links		Trunk Links			Spares
236.5	634	702	757	849	685
238.5	636	704	759	850	687.5
240.5	637.5	705	760.5	851	689
244.5	638.5	706	762.5	852	691
246.5	640	707	764	853	692.5
248.5	641	708	766	854	696
264.5	642.5	709	768	855	697
272.5	644.5	710.5	769	856	698
285.5	646	712.5	771.5	858.5	700
287.5	647.5	714	773	859.5	701
294.5	648.5	715.5	775	860.5	
299.5	649.5	716.5	776.5	861.5	909
302.5	651.5	718	780	874	910
311.5	652.5	720	781	875	912.5
320.5	654.5	721.5	782	876	917
325.5	656.5	722.5	784	877	918
360.5	657.5	724	785	903	919
367.5	659.5	725	786	904	920
370.5	660.5	726.5	788	905	921
373.5	662.5	728.5	789	906	922
376.5	664.5	730	790	907	923
378.5	665.5	731.5	791	908	
386.5	667.5	732.5	792		
388.5	668.5	733.5	793		
390.5	670.5	735.5	794		
394.5	673	736.5	795		
396.5	675	738.5	796		
398.5	676.5	740.5	797		
	678.5	741.5	798		
623	680	743.5	800.5		
624	682	744.5	801.5		
625	684	746.5	802.5		
626.5		748.5	803.5		
628.5		749.5	804.5		
630		751.5	805.5		
631.5		752.5	806.5		
632.5		754.5	807.5		

g. Each corps has absolute control over the assignment of frequencies to its own communication system and the amount of co-ordination required between adjacent corps is minimal.

Application of the Plan and Results Achieved

35. A frequency assignment was made to each corps communication system in turn, independently of the other corps systems. Frequencies were first assigned to Formation HQ links and then to trunk links, using the relevant frequency lists.

a. Assignment to Formation HQ Links

(1) Only 68 frequencies are available for Formation HQ links, 28 of which are in the band 225-400 Mc/s and 40 in the band 622-790 Mc/s. In order to make one pair of the lower frequencies available to each Formation HQ most requiring them, and also to provide some reserve frequencies for possible additional formations and other contingencies, it was decided to include a number of the rearmost HQ in the trunk system for frequency assignment purposes. In most cases it was sufficient to treat only the four links to Main Corps HQ and two links to Rear Corps HQ in this way, but in a corps with a large number of formations (such as the German Corps), it was necessary to include one of the Rear Division HQ. There is an added advantage in including the four links to Main Corps in the trunk system as the compatibility of frequencies at the Corps HQ terminal is better assured by use of the Quadrant Plan.

(2) To obtain maximum frequency separation in each divisional area, frequencies in rising order were ear-marked for assignment in turn to divisions from left to right of each corps front. Table IV (overleaf) shows this arrangement for a typical corps of three divisions, together with the pairing of frequencies in each band ready for assignment to links as receive frequencies.

(3) Frequency pairs in the lower band were assigned to Formation HQ working links and pairs in the higher band to alternate links, as shown in Table IV. In every case the lower frequency of each pair was assigned at the Formation HQ end of the link. (It is not important at which end of the link the lower frequency is assigned but it must be assigned at the same end of every link, otherwise frequency compatibility will be prejudiced.)

(4) The frequencies assigned to Formation HQ links can remain in use irrespective of movement or change of nodal point. They will, however, be subject to normal change at preselected times.

b. Assignment to Trunk Links

(1) Frequencies were assigned in accordance with the modified Quadrant method, described in Annex "C", to all trunk links and the remaining Formation HQ links.

TABLE IV

DISTRIBUTION TO DIVISIONS AND PAIRING OF FORMATION HQ LINK FREQUENCIES
(using List "A" frequencies)

Distribution of Formation Headquarter Link Frequencies

Left Division (3 Brigades)		Centre Division (3 Brigades)		Right Division (2 Brigades)	
235.5	622.5	237.5	623.5	239.5	624.5
241.5	626	245.5	628	247.5	629.5
249.5	630.5	265.5	632	281.5	633
286.5	634.5	290.5	636.5	298.5	638
300.5	639.5	306.5	640.5	314.5	642
322.5	644	346.5	645.5	366.5	646.5
369.5	648	372.5	649	374.5	650.5
377.5	652	382.5	653.5	387.5	655.5
389.5	657	392.5	658.5	395.5	660
397.5	661.5	399.5	663.5		665
	666.5		668		669.5
	671.5		674		676
	677		679.5		681
	683				

Pairing of Formation Headquarter Link Frequencies For Assignment as Receive Frequencies

	Left Division	Centre Division	Right Division
a. **Working Links**			
	235.5 - 322.5	237.5 - 346.5	239.5 - 366.5
	241.5 - 369.5	245.5 - 372.5	247.5 - 374.5
	249.5 - 377.5	265.5 - 382.5	281.5 - 387.5
	286.5 - 389.5	290.5 - 392.5	298.5 - 395.5
	300.5 - 397.5	306.5 - 399.5	
b. **Alternate Links**			
	622.5 - 652	628 - 658.5	624.5 - 655.5
	626 - 657	632 - 663.5	629.5 - 660
	630.5 - 661.5	636.5 - 668	633 - 665
	634.5 - 666.5	640.5 - 674	638 - 669.5
	639.5 - 671.5	645.5 - 679.5	
c. **Corps Reserve Frequencies (showing possible pairing)**			
	644 - 677	623.5 - 649	314.5
	648 - 683	653.5	642 - 676
			646.5 - 681
			650.5

Note: It is possible for more than one working or alternate link to connect into a single nodal point and the frequency pairs assigned to these links must therefore be compatible. The method of pairing shown at a. and b. above assures that the minimum permissible frequency separations are maintained for any combination of pairs within each of the divisional areas.

(2) In the case of flank links interconnecting the various corps networks, receive frequencies were assigned as if by each corps to its own end of the links. The only condition for this method to assure frequency compatibility is that the nodal points linked shall not be assigned the same letter A, B or M. In practice this can be achieved by a standing arrangement mutually agreed between the corps concerned, but whatever method is adopted, some co-ordination between corps is essential, both as regards lettering of the nodal points concerned and the subsequent notification to each other of the frequencies assigned.

36. The frequency assignments were studied both as individual corps assignments and also, combined, as an Army Group frequency assignment to the entire Forward Combat Zone of NORTHAG. The results were as follows:

a. Frequency Separation

All frequency compatibility rules were fully met except for an average of one case of 30 Mc/s and one of 60 Mc/s undesirable separation in each corps system. There were no cases of two transmitters at a nodal point being assigned the same frequency.

b. Frequency Repetition

Laterally, across the Army Group front, no frequency was repeated at less than about 80 km. Within corps boundaries, no frequency was repeated at less than about 60 km but this distance was achieved only by considerable care and time-consuming trial and error on the part of the frequency assigner.

c. Redeployments

The same war game redeployments of the British Corps communication system were used as in the earlier application of the Quadrant Plan. By comparison, they presented little problem as the Formation HQ were able to move at will without reference to the frequency assigner. However, it should not be overlooked that redeployment involving nodal points could be on such a scale as to necessitate a complete re-assignment of frequencies to the whole communication system. As in the case of the Quadrant Plan (Paragraph 20 c), redeployments sometimes result in nodal points having the same letter A, B or M being linked together. This can be overcome by using spare frequencies at both ends of such links.

d. Cross-Linking

The same remarks apply as for the Quadrant Plan (see Paragraph 20 d).

e. Expansion of Communication Systems

The same remarks apply as for the Quadrant Plan (see Paragraph 20 e).

f. Assignment Time

After making all necessary preparations, it took 2-2½ hours to make an initial assignment of frequencies to the trunk communication system for a corps area. However, as the assignments in each corps can be made independently and therefore concurrently, the assignment time required for an Army Group is also 2-2½ hours.

The time taken to re-assign frequencies as a result of the war game redeployments was about 15 minutes, including essential preparations. However, this could increase to 2-2½ hours in addition to the time required for preparations (about 1 hour) in circumstances requiring a re-assignment of frequencies to the whole communication system.

37. **Summary of Results**

a. The frequency compatibility rules were broadly met.

b. Frequency repetition distances were not less than 60 km in any direction.

c. Redeployment on a normal scale were no problem to the frequency assigner; on a scale necessitating re-assignment to a complete system, the time required is likely to be unacceptable.

d. Cross-linking of nodal points and expansion of communication systems posed minor problems which were readily solved.

e. The time required for frequency assignment to all or individual corps communication systems was:

2-2½ hours for an initial deployment.

15 minutes for subsequent war game deployments, but this could be very much longer for major redeployments.

Discussion of Results

38. The results of applying the modified Quadrant Plan in conjunction with frequency grouping were encouraging and it appeared that this method of frequency assignment within an Army Group could go far towards meeting the aim of the study.

39. However, the plan has two related drawbacks which, although not sufficiently serious to render the method ineffective, are likely to pose vexatious problems for the frequency assigner. They are:

a. The amount of laborious and time-consuming trial and error required by the frequency assigner to avoid premature repetition of frequencies (see Paragraph 36 b). This entails moving as many as half of the nodal points from their appointed quadrant squares to any one of the adjacent squares (eight in each case) which gives a satisfactory, although not necessarily the best, solution.

b. The excessive time required to re-assign frequencies to the whole of a corps communication system as a result of a major redeployment, particularly an unpremeditated one. This would be 3-3½ hours (see Paragraph 36 f) and although such cases are likely to be rare, they cannot be ignored.

The time required for assigning frequencies on initial deployment is usually of little consequence as plans are made well in advance. However, in the case of redeployments, many of which are likely to be unpremeditated, time will be of greater significance and the aim should be to re-assign frequencies at least as quickly as the redeployments can be accomplished physically.

39. The study was therefore continued with a view to eliminating these drawbacks, both of which result from use of the quadrant overlay by a central frequency assigner.

40. As stated in Paragraph 19, the Quadrant Plan has three main aims. It has been shown that the plan, as now modified and used,

a. still broadly meets the first aim of assuring compatibility of frequencies at every nodal point;

b. fails to meet the second aim of assuring adequate frequency repetition distances, although this may be overcome by using a central frequency assigner;

c. fails to meet the third aim of decentralised assignment because of the repetition problem above.

41. Therefore the Modified Quadrant Plan is used solely to fix frequency separations between transmitters and receivers, and receivers and receivers, at nodal points. As stated in Paragraph 19 a, the A-B-M method incorporated in the plan sets the transmitter-receiver frequency separation. The receiver-receiver frequency separation alone is set by the quadrant overlay and this is the only purpose the quadrant overlay now serves.

42. However, the same result can be achieved by further grouping of the frequencies in the A-B-M pattern to set the receiver-receiver frequency separation, thus retaining all the useful features of the Quadrant Plan but dispensing with the quadrant overlay. This new plan is discussed in the following section.

THE MODIFIED A-B-M PLAN AND FREQUENCY GROUPING

The Modified A-B-M Plan

43. A description of the Modified A-B-M Plan and the method of applying it to frequency assignment are given at Annex "D".

Frequency Grouping

44. The method of grouping frequencies for use in the respective corps areas is the same as that used in conjunction with the Modified Quadrant Plan and explained in Paragraph 31.

Features of the Plan

45. This plan in no way detracts from the desirable features of the Modified Quadrant Plan listed in Paragraph 34. It does, however, introduce the following additional features:

a. All the data necessary for the assignment are contained on one piece of paper, which also serves as a record of frequencies assigned. The plan is extremely simple to operate.

b. The preparations necessary before making an assignment are greatly reduced as no quadrant overlay is required, nor is a diagram of the network drawn accurately to scale. The frequency assigner must, however, have a rough idea of the distances between nodal points and their geographic relation to each other.

c. The receiver-receiver frequency separation can be chosen at any value between 1 and say 4 Mc/s to suit equipment or radiated power requirements. Generally, the greater the separation, the less chance there is of interference.

d. Nodal points are no longer confined to a maximum of 8 links. The number can be increased to 10 at a receiver-receiver separation of 3 Mc/s, or to 16 at a separation of 2 Mc/s using a 96-frequency list.

e. Maximum possible frequency repetition distances can be achieved. This is because the frequency assigner can now see at a glance where he previously used a frequency and can select the one used farthest away. If considered desirable, the maximum repetition distance within corps communication systems can be reduced simply by reducing the number of frequencies in the A-B-M lists from 96 to not less than 60.

f. Available frequencies are used in such a way as to reduce frequency re-use to a minimum. Again, this is because the frequency assigner can see at a glance all the unused frequencies and can arrange to use the majority of them before resorting to repetition.

Application of the Plan and Results Achieved

46. A frequency assignment was made to each of the corps communication systems in turn. Assignment to Formation HQ links was made in exactly the same way as explained in Paragraph 35 a. Assignment to trunk links was in accordance with the Modified A-B-M Plan described in Annex "D".

47. The actual assignments made to the respective corps communication systems are reproduced at the following Annexes:

Annex E.1 - 1(NL) Corps
Annex E.2 - 1(GE) Corps
Annex E.3 - 1(BR) Corps
Annex E.4 - 1(BE) Corps

48. The frequency assignments were studied both from the corps and Army Group aspects. The results were as follows:

a. Frequency Separation

All frequency compatibility rules were fully met except for isolated cases of undesirable separations of 30 Mc/s or 60 Mc/s. These were remedied by substituting suitable frequencies from the A-B-M list or spare frequency list.

b. Frequency Repetition

Laterally, the frequency repetition distance remained the same as for the Modified Quadrant Plan, at not less than 80 km. Within corps boundaries, no frequency was repeated at less than 80 km.

c. Redeployments

The same war game redeployments of the British Corps communication system were used as previously. Re-assignment of frequencies was very rapid and presented no problem. A redeployment involving re-assignment of frequencies to the whole of a corps communication system would no longer pose a problem as it would be completed more quickly than the redeployment could be accomplished physically.

d. Cross-Linking

The same remarks apply as for the Quadrant Plan (see Paragraph 20 d).

e. Expansion of Communication Systems

The same remarks apply as for the Quadrant Plan (see Paragraph 20 e).

f. Assignment Time

After making all necessary preparations, it took $\frac{1}{2}$ hour to make an initial assignment of frequencies to the trunk communication system in each corps area. If assignments are made simultaneously in each corps area, the time required for an Army Group is also $\frac{1}{2}$ hour. For re-assignment of frequencies necessitated by the war game redeployments, the time taken was about 5 minutes, including essential preparations. A major redeployment requiring complete re-assignment of frequencies to a corps communication system would entail drawing the new system roughly to scale and assigning the letters A, B or M to nodal points ($\frac{1}{4}$ hour) and re-assigning frequencies ($\frac{1}{2}$ hour); taking a total of $\frac{3}{4}$ hour.

49. Summary of Results

a. The frequency compatibility rules were broadly met.

b. Frequency repetition distances were not less than 80 km in any direction.

c. Redeployments were easily and quickly catered for.

d. Cross-linking of nodal points and expansion of communication systems posed minor problems which were easily solved.

e. The time required for assignment of frequencies to all or individual corps communication systems was:

$\frac{1}{2}$ hour for an initial deployment

5 minutes for subsequent war game redeployments, but this could increase to $\frac{3}{4}$ hour for a redeployment of the whole network.

Discussion of Results

50. The results indicate that the Modified A-B-M Plan, used in conjunction with frequency grouping and the number of frequencies currently available, is a satisfactory method of assigning frequencies on an Army Group basis and meets the aim of the study. The study of methods was therefore concluded.

GENERAL SUMMARY OF ASSIGNMENT METHODS

51. A comparative table summarizing the results of assigning frequencies using the Quadrant Plan, the Modified Quadrant Plan and the Modified A-B-M Plan is attached at Annex "F".

52. It will be noted that in all cases the frequency compatibility rules are not fully met. This is because purely mechanical operation of any of the three plans occasionally fails to comply with the compatibility rules relating to undesirable separations of 30 Mc/s and 60 Mc/s. However, these rare cases can readily be spotted and remedied by substituting compatible spare frequencies.

53. An analysis of the frequencies assigned to 1(BR) Corps communication system using the Quadrant Plan with and without central control, the Modified Quadrant Plan and the Modified A-B-M Plan is attached at Annex "G". The actual frequency assignments are held at DOAE.

54. None of the three methods requires more frequencies than are currently allotted to NORTHAG for use in war. However, it is desirable to have 24 additional frequencies, preferably in the 225-400 Mc/s band, so that all Formation HQ links in a large corps of 4 divisions and 12 brigades can be assigned frequencies separate from the trunk link assignment (Paragraph 35 a refers).

ADDITIONAL CONSIDERATIONS

Use of High Power Radiation

55. As stated in Paragraph 6 b, this study assumed that radio relay sets would operate on low power, as reflected in the frequency compatibility rules.

56. There may be occasions when the use of high power on a link is justifiable. What effect this would have on the rest of the communication system cannot be determined accurately without a new set of compatibility rules. However, the Modified A-B-M method of frequency assignment to trunk links would moderate the effect to some extent because:

a. A minimum transmitter-receiver separation of 16 Mc/s is provided instead of 10 Mc/s required by the rules pertaining to low-power radio relay.

b. The minimum receiver-receiver separation can be set at up to 4 Mc/s against 1 Mc/s required by the rules. The greater the separation, the less likelihood there is of adjacent channel interference at the nodal point receiving the high-power transmission.

c. The frequency repetition distance is the maximum possible, but see Paragraph 58.

d. Formation HQ working links, which are probably the most likely to require high power, operate in the 225-400 Mc/s band and so are unlikely to cause interference to parent communication systems. They could, however, interfere with other corps using the same frequencies or, possibly, with ground-to-air transmissions in the same band.

<u>Frequency Repetition Distance</u>

57. Opinions differ widely as to what can be considered a safe repetition distance. Assuming frequencies are repeated intelligently, as they can be using either the Modified Quadrant Plan or the Modified A-B-M Plan, there is reason to believe that a distance of 60-80 km is more than adequate to obviate co-channel interference.

58. It may be proved in future trials that the repetition distance can safely be reduced. With the Modified A-B-M Plan, this is simply effected within each Corps communication system by reducing the number of frequencies in the A-B-M lists. However, this course is not recommended; the repetition distance should always be the maximum that the available frequencies will allow in order to:

a. Facilitate frequency assignment to new nodal points which may be established inside an existing communications system.

b. Minimize the likelihood of co-channel interference should a link be forced to operate on high power.

<u>Extension of the Frequency Assignment Method</u>

59. Although the detailed study of frequency assignment methods was confined entirely to NORTHAG Forward Combat Zone, thought was also given to other areas.

60. The area of application of both the Modified Quadrant Plan and the Modified A-B-M Plan can readily be extended:

a. To include the whole of Central Europe Forward Communication Zone, using the same frequency lists as those devised for NORTHAG and allotting them alternately to corps from left to right across the whole front.

b. On a national basis to the Rear Combat Communication Zones, provided the assignment areas are clearly defined by extension of corps boundaries

rearwards and provided there is adequate co-ordination between the separately controlled systems within these boundaries. Until there is a firm communication plan for the rearward areas, the problems of organization and control in general and of frequency assignment in particular cannot be studied objectively.

61. If rear links between corps and Army Group use frequencies in the same bands as the corps systems, the assignment of frequencies to them will require to be co-ordinated between Army Group and the respective corps. In some circumstances it may be found convenient for corps to assign frequencies to these links.

Application of the Frequency Assignment Method to Corps Using Command-Type Systems or a Mixture of Command and Area Systems

62. The appropriate frequency list, representing half the available frequencies, can be issued to each corps irrespective of the type of communication system employed.

63. The method of assigning these frequencies to other than area communication systems can be safely left to the discretion of the corps concerned without risk of prejudicing the frequency assignments in adjacent corps areas or corps areas using the same frequencies.

Application of the Frequency Assignment Method to Corps Using Equipment in Higher or Lower Frequency Bands

64. In this case the frequency List A or B, as appropriate, need not be physically allotted. However, it is advisable to reserve the appropriate list in case the corps is replaced at some future time by one employing equipment in the frequency bands considered by this study. For example, if the German Corps chooses to use equipment in the 1500 Mc/s band, the allotment of frequency lists would be:

List A to 1(NL) Corps.

Nil to 1(GE) Corps; List B reserved.

List A to 1(BR) Corps.

List B to 1(BE) Corps.

65. It is possible that a corps using a different frequency band could cause or suffer harmonic interference, depending on whether the frequency band is lower or higher than that used in adjacent corps areas.

Transfer of a Division from One Corps to Another

66. On leaving the old corps, the division relinquishes all its frequencies. New frequencies for trunk and Formation HQ links will be assigned by the new corps.

Transfer of a Corps from One Army Group to Another or the Addition of a New Corps to an Army Group

67. The corps transferred or added will be allotted the frequency list appropriate to its new position and all corps to right or left,

whichever involves least change, will require to change to new frequency lists at a specified time.

68. The transfer of a corps or the addition of a new corps would take a considerable time to plan and execute, giving ample opportunity for the frequency assigners to make new assignments. A simple method is to replace each frequency assigned from the old list by its corresponding frequency in the new list; the frequency difference in most cases is only 0.5 Mc/s, which minimizes the time required for a network frequency change. The inclusion of an additional corps on an Army Group front may result in reducing the minimum frequency repetition distance laterally but not, it is thought, sufficiently to prejudice the assignment method.

Divisional Control of Frequency Assignment

69. It is known that some national armies delegate to divisions the responsibility for frequency assignment to divisional communication systems. Neither the Modified Quadrant Plan nor the Modified A-B-M Plan lends itself to decentralised application to the trunk communication system, which must be treated as a fully integrated whole, but responsibility for assigning Formation HQ link frequencies might well be delegated to divisions.

70. The frequency grouping associated with both the Modified Quadrant Plan and the Modified A-B-M Plan makes it possible for a corps to devise any method of frequency assignment that best suits its purposes, provided that it demands no more frequencies than are included in the allotted frequency lists.

Fixed UHF Stations in North-West Europe

71. No information is available regarding fixed civil and military UHF stations in North-West Europe which will continue to operate in war. This study has therefore not taken into account the possibility of mutual interference between such installations and the military mobile radio relay communication systems.

Frequency Assignments for Peacetime Exercising of Communication Systems

72. The frequencies available to NORTHAG for peacetime use of military mobile radio relay are as follows:

Band 225-400 Mc/s	-	57
Band 790-960 Mc/s	-	96
Total		153

73. These are clearly inadequate to enable all corps communication systems to operate simultaneously but it is considered unlikely, for reasons of security, administration, troop welfare, etc., that there would be a requirement to establish corps radio relay communication systems on a permanent basis in peacetime. The requirement is more likely to be to exercise individual corps communication systems periodically.

74. There are two possible ways of achieving this

a. By allotting, temporarily, all the available frequencies on a priority or non-interference basis, as appropriate, to the corps being exercised. The 57 frequencies in the

lower band are sufficient for assignment to the Formation HQ links of 3 divisions and 8 brigades. The 96 frequencies in the higher band can then be assigned to trunk links by the Modified A-B-M Plan, using say 84 frequencies and leaving 12 spares; these frequencies are sufficient for a full corps network without excessive repetition. In the lower frequency band the channel separation is at least 1 Mc/s but mainly only 0.5 Mc/s in the higher frequency band. However, using the Modified A-B-M Plan, it is not difficult to achieve the minimum frequency separations required at most nodal points. Use of this method of frequency assignment would enable two or more corps to exercise simultaneously, provided they are given adequate geographic spacing. The Modified Quadrant Plan is unsuitable in this case as it requires 96 frequencies, leaving no essential spares.

b. By exercising during periods when national television broadcasting is closed down (e.g. at night) and using a sufficient number of frequencies in the 622-790 Mc/s band to supplement the peacetime frequencies normally allotted to the corps. The communication links could be engineered on a phased programme during daytime, using the frequencies normally allotted to the military. This method would, of course, require the agreement of the national broadcasting authorities concerned.

CONCLUSIONS

75. The main conclusions arising from the study are:

a. The Modified A-B-M Plan, in conjunction with frequency grouping, is the most suitable manual method of assigning a limited number of frequencies to military radio relay area communication systems in the Forward Combat Zone of an Army Group.

b. This plan appears to make possible the assignment of frequencies to area communication systems of the ALLERTON (HOBART) type, if used by all corps in Europe, within the frequencies currently allotted to the military in war in bands 225-960 Mc/s (but see sub-paragraph c below). Adoption of the plan would involve re-allocation of frequencies by Army Groups to the respective corps.

c. It is desirable to have 24 additional frequencies, preferably in the band 225-400 Mc/s, so that, even in the largest corps, all Formation HQ links can be assigned frequencies separate from the trunk link assignment (vide Paragraph 35 a).

d. As stated in Paragraph 57, based on the best information currently available there is reason to believe that a frequency repetition distance of 60-80 km is more than adequate to obviate co-channel interference. It would, however, be of advantage to determine the extent to which this distance can safely be reduced and to this end it is considered desirable for trials to be carried out on the ground.

RECOMMENDATIONS

76. It is recommended that:

a. The results of this study are communicated to the national authorities and NATO Headquarters concerned, noting that, in the planning of area communication systems, satisfactory operation will be possible within the frequencies currently available to the military in war provided that unanimous agreement is given to the allocation of frequency lists, similar to A and B used in this study, to all corps in Central Europe, irrespective of the method of frequency assignment to be used within each corps (Paragraphs 31-33 refer). If this recommended allocation of frequencies is implemented, the Modified A-B-M Plan (Paragraph 43 et seq) should be adopted as the standard manual method of assigning frequencies to corps area communication systems: if it is not implemented, it is impracticable for any corps, unilaterally, to use the Modified A-B-M Plan or any other plan as envisaged in this study.

b. Steps are taken by SHAPE to secure at least 24 additional frequencies, as many as possible in the 225-400 Mc/s band, so that all Formation HQ links can be assigned frequencies separate from the trunk link assignments (Paragraph 35a and 75c refer).

c. Nations concerned should develop or use equipment whose spectrum signature is at least as "clean" as that predicted for AN/GRC-103 (vide Paragraph 10-12).

d. Trials on the ground are carried out as soon as possible to reduce the uncertainty regarding the minimum distance at which co-channel repetition of frequencies is possible (Paragraphs 57, 58 and 75d refer).

REFERENCES

1. AORE Report No. 4/63; HOBART Radio Relay Frequency Accommodation. July 1963. (SECRET)

2. HOBART - Royal Signals Planning Wing Study No. 27. February 1962. (SECRET)

3. DOAE Research Memorandum No. 1/65; A Deployment of the HOBART Area Communication System in a General War Setting in North-West Europe. February 1965. (SECRET)

4. DOAE Research Memorandum No. 9/65; Rules for Assigning Frequencies to Radio Relay Links in an Area Communication System of HOBART (ALLERTON) Type. September 1965. (CONFIDENTIAL)

ANNEX "A"

THE SIX-WAY LINEAR LATTICE METHOD OF FREQUENCY ASSIGNMENT

Description

A.1. A typical example of a six-way linear lattice is attached at Appendix A.1.

A.2. The lattice pattern represents an idealized system of communication links and is drawn sufficiently large to cover the whole of the assignment area, with link lengths approximately equal to the average length of communication links.

A.3. Transmitter frequencies are pre-assigned to the six links at each node in the lattice and when all available frequencies have been used once, they are systematically re-used in a repetitive pattern.

A.4. The number of frequencies required to operate the lattice method is governed by the minimum frequency repetition distance necessary. The following are examples of the basic repetition distance/frequencies required relationship when using 10-km lattice links:

A repetition distance of 50 km requires 150 frequencies

A repetition distance of 60 km requires 216 frequencies

A repetition distance of 70 km requires 294 frequencies

A repetition distance of 80 km requires 384 frequencies.

However, because of the need to distort the lattice to correspond to the communication layout (vide Paragraph A.6), the actual repetition distance after assignment may vary considerably from the basic repetition distance on which the lattice assignment was planned and allowance must be made for this.

Method of Assignment

A.5. Available frequencies are arranged in pairs drawn from two equal blocks of frequencies so that the separation between the frequencies in each pair exceeds twice the intermediate frequency of the receivers in use. This obviates the majority of receiver spurious responses. The frequency pairs are then assigned to all lattice links by an iterative process so that:

a. At each nodal point 4 transmit frequencies are in the block of higher frequencies and two in the block of lower frequencies, or vice versa, as indicated by the high and low (H/L) markings at Appendix A.1.

b. The frequency separations within nodal points and individual vehicles satisfy the separation rules.

A.6. Next the lattice is distorted so that its nodes correspond to the nodal points in the communication layout. "Holes" (unused nodes) in the lattice should be avoided as they cannot be bridged by links, although peripheral nodes may be unused. Links in the communication network are now identified with appropriate lattice links and assume the frequencies already assigned to the latter.

A.7. Redeployment of a nodal point entails the following:

a. If the move is from one peripheral position in the network to another, the nodal point is associated with an appropriate node in the lattice and its new links are assigned the same frequencies as the corresponding lattice links. No other nodal point is involved in a general frequency change.

b. For all other moves it is necessary to distort the lattice pattern so that it corresponds to the modified network, and to re-assign frequencies in the way already described. This involves a number of nodal points, in addition to the one which is moving, in a general frequency change.

<u>An Alternative Method of Assignment</u>

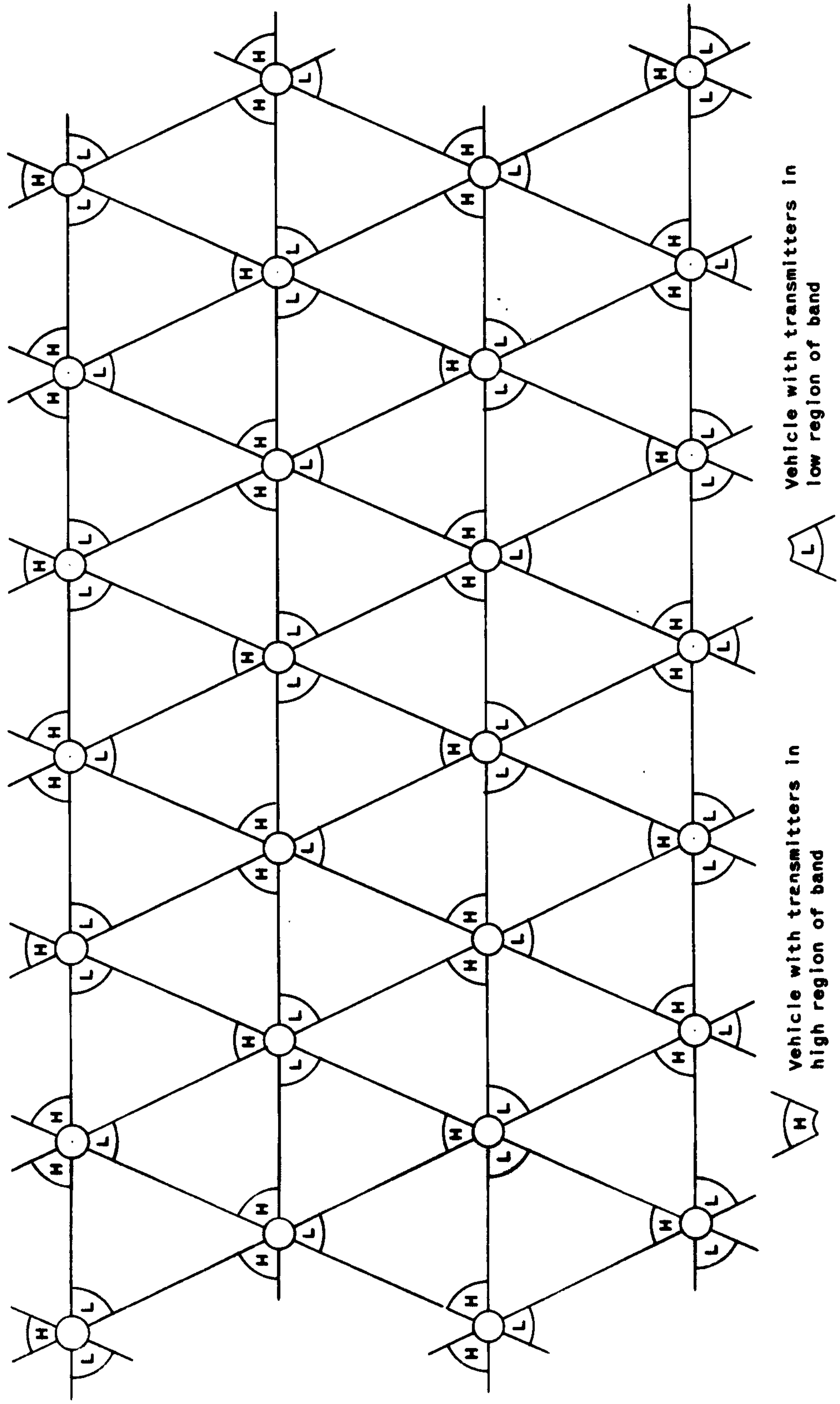
A.8. When the number of frequencies available is insufficient to assure the repetition distance required using the method described above, it is possible for the Six-Way Linear Lattice to be used for frequency assignment in a different way.

A.9. Instead of pre-assigning frequencies to the whole lattice, assignments are made directly to the communication links, using the lattice as a guide.

A.10. The frequencies are paired as described in Paragraph A.5 and the lattice distorted to correspond to the communication network as described in Paragraph A.6. Transmit frequencies are then assigned to the communication links in accordance with the H/L markings on the corresponding lattice links.

A.11. This method has the advantage of being operable when the number of available frequencies is very limited. However, because assignment is now arbitrary, does not accord with any pattern, and frequency repetition distances are no longer fixed, central control of assignment over the whole operational area is necessary. This would be possible for an isolated corps system but central control of assignment on an Army Group basis would be impracticable. Control of assignment could be delegated to corps, if adjacent corps use separate frequency lists, but the circumstances in which this alternative method would be considered (vide Paragraph A.8) are likely to preclude the allotment of separate frequency lists to adjacent corps.

THE SIX-WAY LINEAR LATTICE



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ANNEX "B"

THE QUADRANT PLAN

Outline Description

B.1. The Quadrant Plan is designed to control the separation of frequencies assigned to radio relay communication systems in both frequency and distance without the necessity for extensive co-ordination or rigid central control.

B.2. The ground over which frequencies are to be assigned is divided into assignment areas called "squares". Nine of these squares make up a quarter quadrant, four quarters form one quadrant, and four quadrants form the basis of a repetitive pattern. The arrangement is shown at Appendix B.1.

B.3. The size of the quadrant square is not critical but the length should be rather less than the average length of links in the communication system. Whenever practicable, it is convenient for the quadrant square to be the same size as the grid squares on the maps in use.

B.4. The Quadrant Plan incorporates the A-B-M Method of assigning the letters A, B or M to nodal points in the communication system and of grouping frequencies to fix a separation of 24 channel numbers minimum between receive and transmit frequencies at every nodal point.

B.5. The plan requires 144 frequencies. These are listed in rising frequency order in six lists, one for each possible type of link, as shown at Appendix B.2. There are 24 frequencies in each list and they are given list numbers which apply to all six lists.

B.6. The frequency list numbers are allotted to quadrant squares, one list number for each of four directions of reception (see Appendix B.1). In any one square every sixth frequency list number is allotted; this ensures a minimum separation of 6 channel numbers between receive frequencies at any one nodal point.

B.7. The plan provides for a maximum of 8 links at any one nodal point; e.g. B to A and M to A from each of the four directions.

B.8. A maximum of 3 nodal points may be sited in any one square provided they are assigned different letters; A, B and M.

Method of Assignment

B.9. Drawn the communication network to the same scale as the quadrant overlay (see Paragraph B.2), assign the letter A, B or M to each nodal point so that like letters are not connected (e.g. A connects only to a B or M), lay the quadrant overlay over the network diagram. An example of a network diagram with letters A, B and M assigned and quadrant overlay superimposed is given at Appendix B.3.

B.10. Receive frequencies are assigned to the links at each nodal point by identifying each link with the frequency list number appropriate to the direction of reception and then reading off the frequency in the list pertaining to the type of link; e.g. B to A (Appendix B.2 refers). The following example of assignment of frequencies (channel numbers) at Nodal Point 3 (Appendix B.3) will help to explain the method:

a. The link from Nodal Point 6 is coming in from the North. The frequency list number for this direction is 20. The type of link is M to A. Reference to Appendix B.2 shows that the frequency (channel number) with list number 20 for link M to A is 116;

b. the link from Nodal Point 7 is from the South. The frequency list number is 8. The type of link is B to A. The frequency (channel number) with list number 8 for link B to A is 80;

and so on for the links from Nodal Points 4 and 2. Having assigned the receive frequencies, the transmit frequencies at the distant end of the respective links are automatically determined.

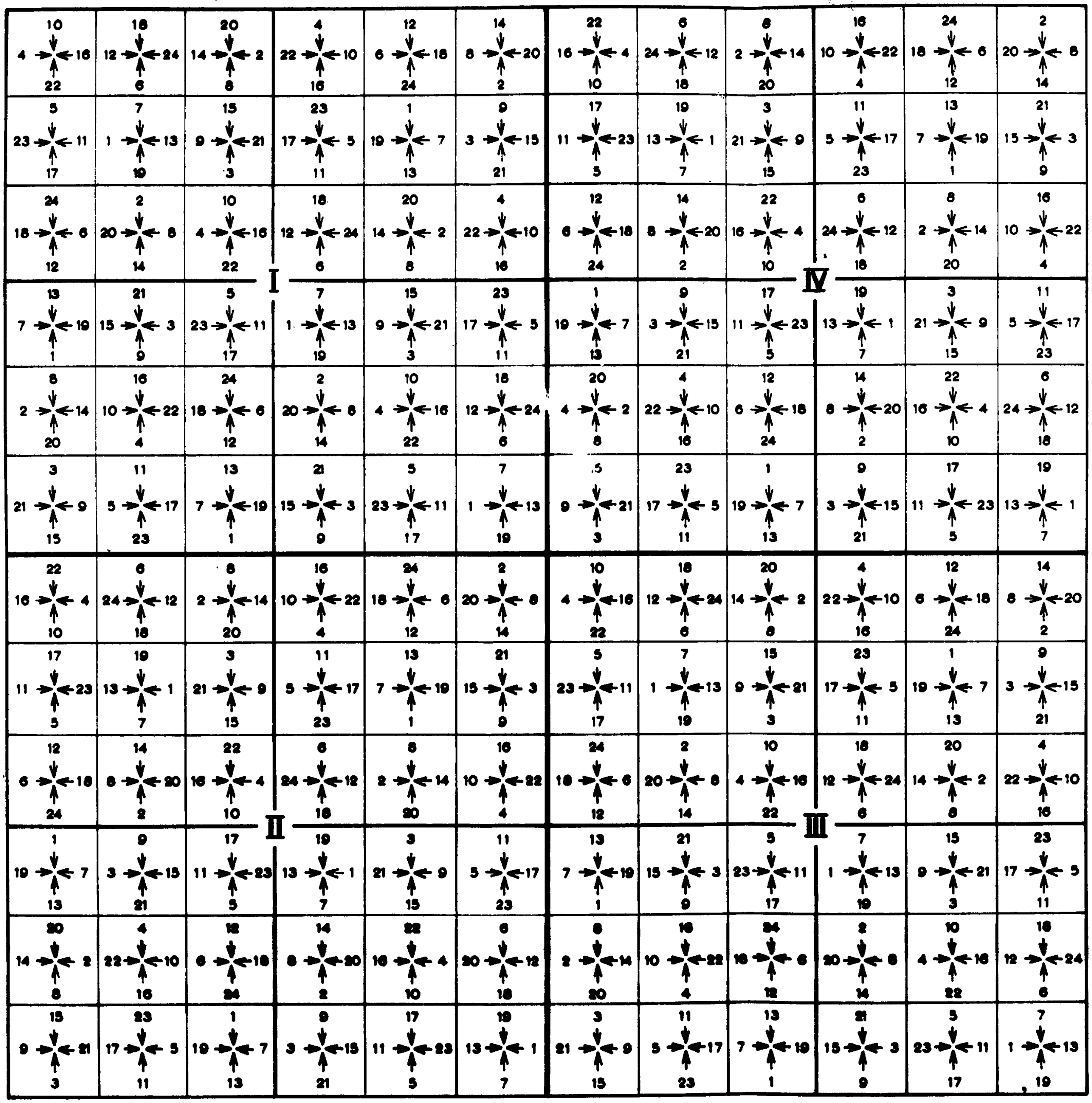
B.11. Where two links exist between two nodal points, frequencies are assigned to the second link as if each nodal point were in one of the adjacent squares. In such cases it is necessary to check visually that frequencies "borrowed" from adjacent squares are compatible with all other transmit and receive frequencies in use at the nodal points concerned.

B.12. Redeployment of a nodal point entails recovering all frequencies previously assigned to both ends of the links connecting to it; modifying the network diagram; assigning the letter A, B or M to the nodal point in its new position; and re-assigning frequencies appropriate to its new quadrant square.

B.13. The simplest way of implementing a frequency change of the entire network is by changing the co-ordinates of the quadrant overlay and re-assigning new frequencies.

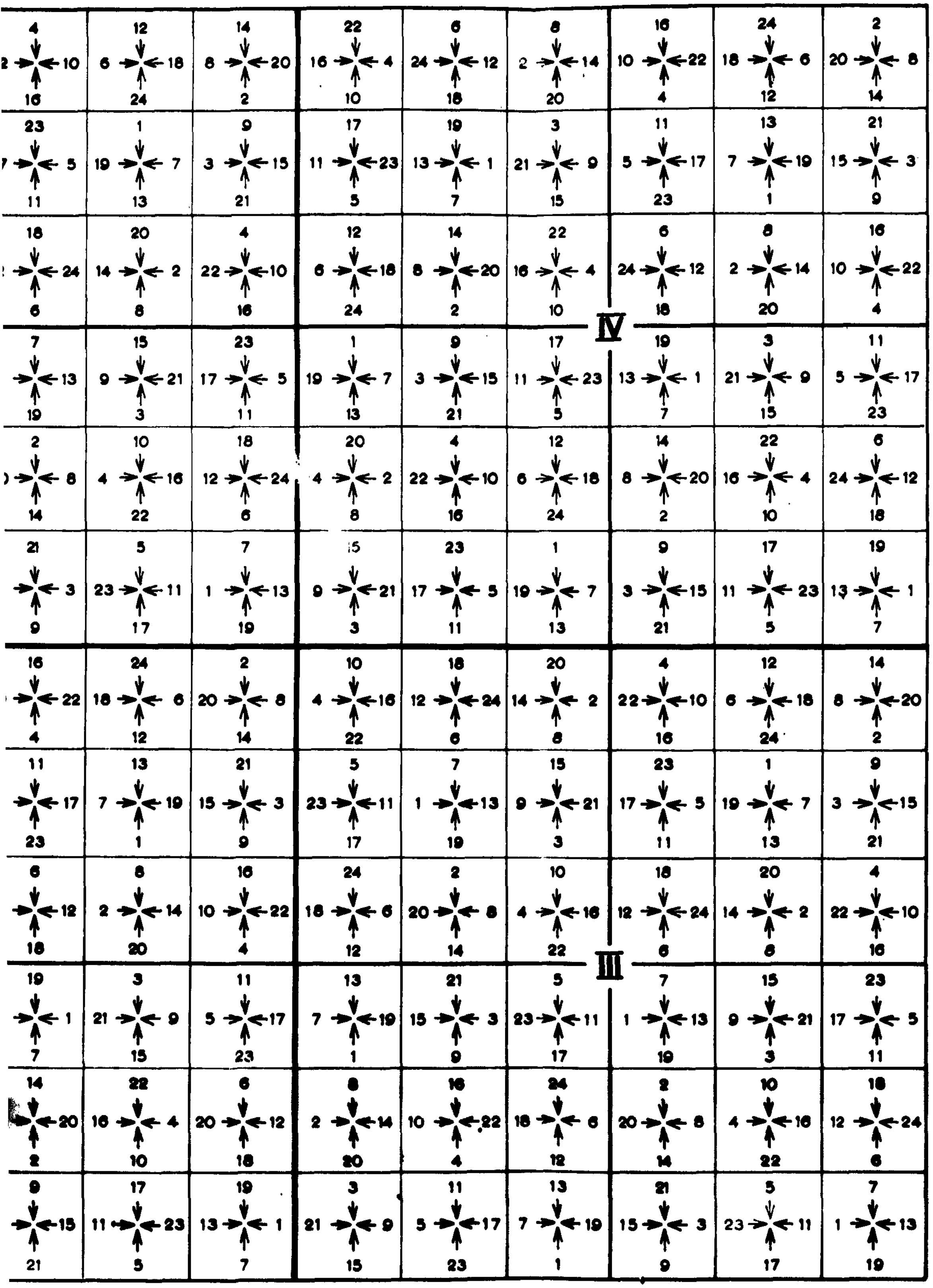
THE QUADRANT OVERLAY

(Showing a set of 4 Quadrants, I to IV and, inset, the arrangement of quadrants to form a r



THE QUADRANT OVERLAY

(... of 4 Quadrants, I to IV and, inset, the arrangement of quadrants to form a repetitive pattern)



IV	I	IV	I	IV	I	IV
III	II	III	II	III	II	III
IV	I	IV	I	IV	I	IV
III	II	III	II	III	II	III
IV	I	IV	I	IV	I	IV

Notes

1. Each square is assigned four frequency list numbers (see Appendix B.2), being one for each direction of reception.

2. The groups of four frequency list numbers assigned to squares are evenly rotated and dispersed throughout the four quadrants.

3. In practice the squares on the quadrant overlay would not contain the frequency list numbers but a single square number. This number would be separately identified with the grouping of frequency list numbers shown in this appendix.

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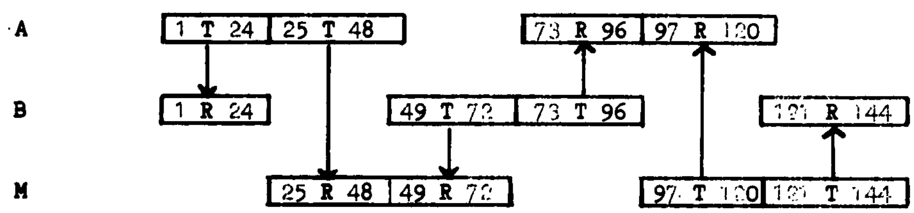
Appendix B.

FREQUENCY LISTS IN A-B-M PATTERN

Frequency List Nos.	A to B	A to M	B to M	B to A	M to A	M to B
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	1	25	49	73	97	121
2	2	26	50	74	98	122
3	3	27	51	75	99	123
4	4	28	52	76	100	124
5	5	29	53	77	101	125
6	6	30	54	78	102	126
7	7	31	55	79	103	127
8	8	32	56	80	104	128
9	9	33	57	81	105	129
10	10	34	58	82	106	130
11	11	35	59	83	107	131
12	12	36	60	84	108	132
13	13	37	61	85	109	133
14	14	38	62	86	110	134
15	15	39	63	87	111	135
16	16	40	64	88	112	136
17	17	41	65	89	113	137
18	18	42	66	90	114	138
19	19	43	67	91	115	139
20	20	44	68	92	116	140
21	21	45	69	93	117	141
22	22	46	70	94	118	142
23	23	47	71	95	119	143
24	24	48	72	96	120	144

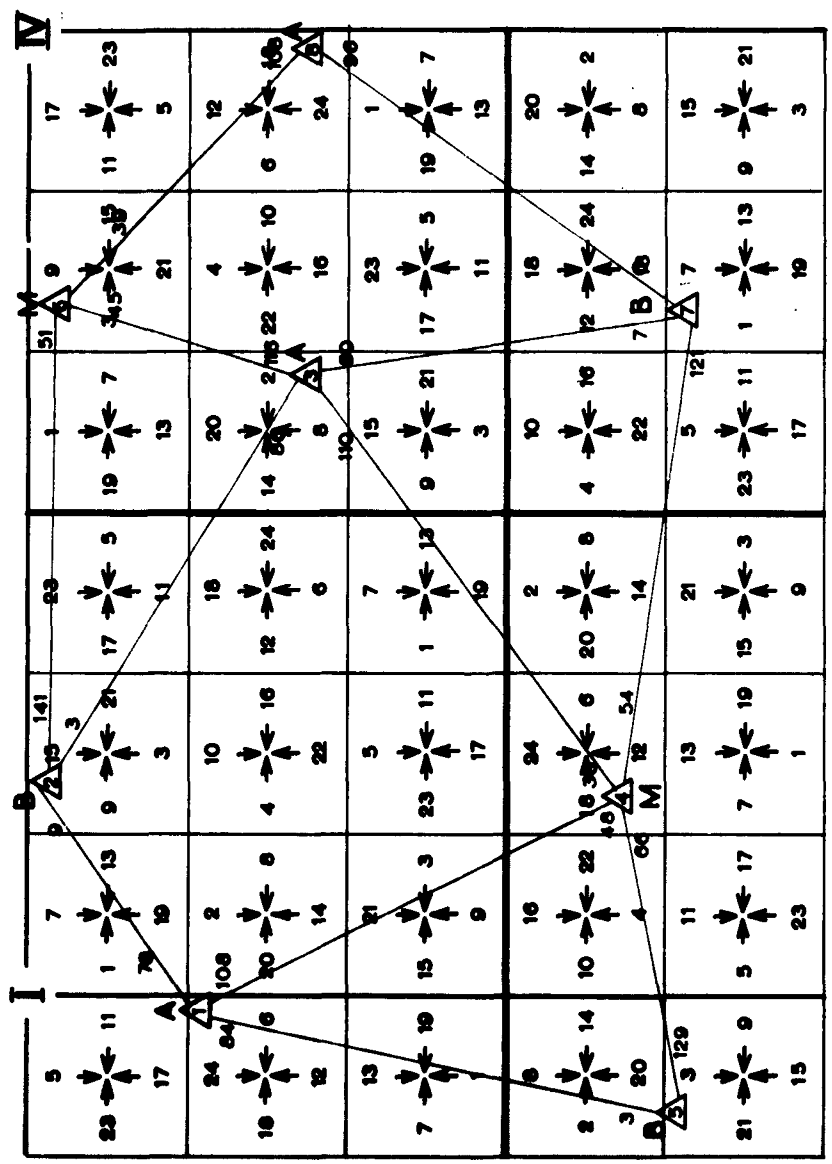


Notes:

1. **For simplicity, channel numbers are shown in Columns (b) to (g) instead of actual frequencies. Frequencies are entered in rising frequency order, starting at the top of Column (b) and working down each column in turn.**

2. This pattern assures a minimum T-R separation of 48 channel numbers on a single link and of [illegible] channel numbers at a nodal point.

AN ASSIGNMENT OF RECEIVE FREQUENCIES (CHANNEL NUMBERS) TO A COMMUNICATION NETWORK



ANNEX "C"

THE MODIFIED QUADRANT PLAN

Outline Description

C.1. The Modified Quadrant Plan is similar to the Quadrant Plan except that the quadrants have a reduced number of squares and fewer frequencies are required to operate it.

C.2. The ground is divided into squares (assignment areas). Four squares make up a quarter quadrant; four quarters form one quadrant; and four quadrants form the basis of a repetitive pattern. The arrangement is shown at Appendix C.1.

C.3. The size of the quadrant square is not critical but the length should be rather less than the average length of communication links. Whenever practicable, it is convenient for the quadrant squares to be the same size as the grid squares on the maps in use.

C.4. The Modified Quadrant Plan incorporates the A-B-M method of assigning the letters A, B or M to nodal points in the communication system and of grouping frequencies to fix a minimum separation of 16 channel numbers between receive and transmit frequencies at every nodal point.

C.5. The plan requires 96 frequencies which are listed in rising frequency order in six lists, one for each possible type of link, as shown at Appendix C.2. There are 16 frequencies in each list and they are given list numbers which apply to all six lists.

C.6. The frequency list numbers are allotted to quadrant squares; one list number for each of four directions of reception (see Appendix C.1). In any one square every fourth frequency list number is allotted; this ensures a minimum separation of 4 channel numbers between receive frequencies at any one nodal point.

C.7. The plan provides for a maximum of 8 links at any nodal point; e.g. A to M and B to M from each of the four directions.

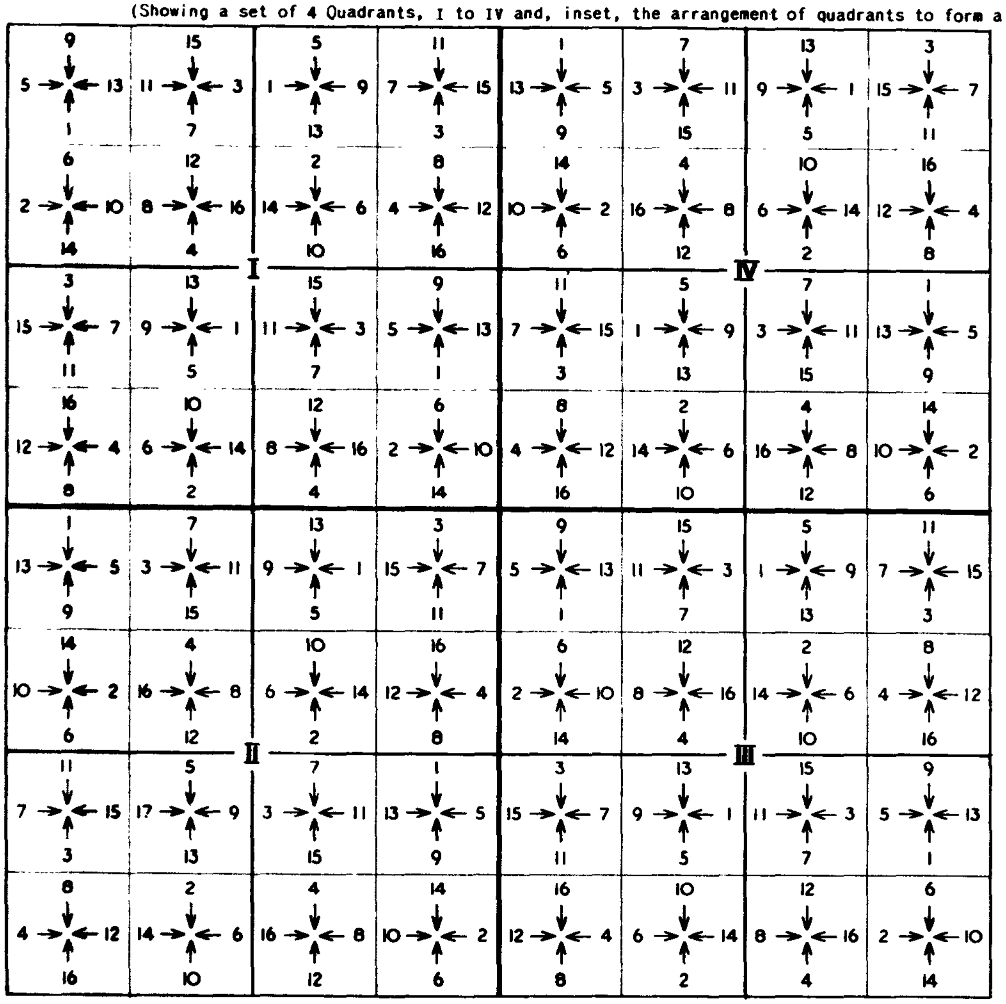
C.8. A maximum of three nodal points may be sited in one square, provided they are assigned different letters; A, B and M.

Method of Assignment

C.9. The method of assigning frequencies is exactly the same as that used with the Quadrant Plan and described in Annex "B".

THE MODIFIED QUADRANT OVERLAY

(Showing a set of 4 Quadrants, I to IV and, inset, the arrangement of quadrants to form a repetitive pattern)



I	IV	I	IV	I	IV
II	III	II	III	II	III
I	IV	I	IV	I	IV
II	III	II	III	II	III
I	IV	I	IV	I	IV

Notes

1. Each square is assigned four frequency list numbers (see Appendix C.2), being one for each direction of reception.

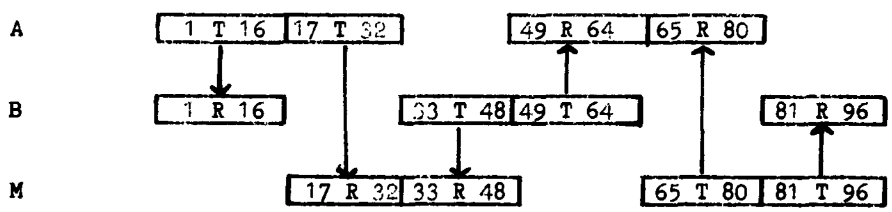
2. The groups of four frequency list numbers assigned to squares are evenly rotated and dispersed throughout the four quadrants.

3. In practice, the squares on the quadrant overlay would not contain the frequency list numbers but a single square number. This number would be separately identified with the grouping of frequency list numbers shown in this appendix.

Appendix C.2

FREQUENCY LISTS IN A-B-M PATTERN

Frequency List Nos.	A to B	A to M	B to M	B to A	M to A	M to B
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	1	17	33	49	65	81
2	2	18	34	50	66	82
3	3	19	35	51	67	83
4	4	20	36	52	68	84
5	5	21	37	53	69	85
6	6	22	38	54	70	86
7	7	23	39	55	71	87
8	8	24	40	56	72	88
9	9	25	41	57	73	89
10	10	26	42	58	74	90
11	11	27	43	59	75	91
12	12	28	44	60	76	92
13	13	29	45	61	77	93
14	14	30	46	62	78	94
15	15	31	47	63	79	95
16	16	32	48	64	80	96



Notes:

1. For simplicity, channel numbers are shown in Columns (b) to (g) instead of actual frequencies. Frequencies are entered in rising frequency order starting at the top of Column (b) and working down each column in turn.

2. This pattern assures a minimum T-R separation of 32 channel numbers on a single link and of 16 channel numbers at a nodal point.

ANNEX "D"

THE MODIFIED A-B-M PLAN

Outline Description

D.1. The Modified A-B-M Plan is designed to assure the compatibility of all frequencies in use at a nodal point in a communication system. It does so by fixing minimum transmitter-receiver, transmitter-transmitter and receiver-receiver frequency separations at nodal points. Provided that these minimum frequency separations can be made to satisfy the compatibility rules for the equipment in use, the plan will operate successfully.

D.2. The basic A-B-M Plan, as incorporated in the Quadrant Plan and shown at Appendix D.1, assures a minimum frequency separation between transmitters and receivers only. However, by taking the basic A-B-M pattern and grouping the frequency list numbers and related frequencies, it is possible to fix the receiver-receiver frequency separation also, provided that each group contains the same number of frequencies. For example, as shown in Appendix D.2, using 96 frequencies and grouping together every fourth frequency list number, four groups each containing 24 frequencies are formed and the separation between consecutive frequencies in each group is 4 channel numbers. Appendix D.3 shows that by grouping together every third frequency list number, three groups each containing 30 frequencies are formed giving a separation of 3 channel numbers in each group. In this case 6 frequencies are left over; these can be grouped provisionally with the next group in turn (Group I) but must be assigned with care as although the correct separation for each link type is assured, this is not true of other link types which may terminate at a nodal point (e.g. referring to Appendix D.3, frequency list number 16 for link type A to M is only one channel number removed from frequency list number 1 for link type B to M).

D.3. It will be found that the greater the receiver-receiver frequency separation required, the less flexibility the frequency assigner has in assigning frequencies.

D.4. As already stated, the examples given in Appendices D.2 and D.3 of modified A-B-M patterns use 96 frequencies. This number gives the following separations at nodal points:

a. Transmitter-receiver - 16 channel numbers

b. Receiver-receiver - Variable value between 1 and 5 channel numbers

c. Transmitter-transmitter - 1 channel number.

D.5. However, the Modified A-B-M Plan can operate with more or less frequencies provided the required frequency separations can be maintained. The minimum number of frequencies necessary is dependent on the minimum transmitter-receiver frequency separation required; e.g. a separation of 10 channel numbers requires 10 frequencies in each of the six A-B-M lists, making a total of 60 frequencies. The more

frequencies available, the greater will be:

a. The transmitter-receiver frequency separation.

b. The choice of receiver-receiver frequency separation.

c. The frequency repetition distance.

d. The number of links which can terminate at a nodal point.

e. The flexibility in making assignments.

Method of Assignment

D.6. Draw the communication network roughly to scale; assign the letter A, B or M to each nodal point so that like letters are not connected (e.g. A connects only to a B or M), and ensuring that approximately the same number of the letters A, B or M are assigned to the network.

D.7. Divide the number of available frequencies by 6 to determine the frequency list numbers and enter these as shown in Appendix D.1. Enter the frequencies in ascending frequency order in 6 lists, starting at the left and working down each list in turn.

D.8. Decide the receiver-receiver frequency separation required. Assuming it is 3 channel numbers, group together every third frequency list number, and the six frequencies associated with each, as shown in Appendix D.4. The resulting frequency pattern is now the sole instrument for assigning frequencies and also serves as a record of assignments. (The number of available frequencies and the receiver-receiver frequency separation, once determined, are likely to remain constant; the modified A-B-M pattern can therefore be produced in quantity and serve for numerous assignments.)

D 9. Frequencies are assigned to nodal points starting at the forward edge of the operational area and working systematically towards the rear.

D.10. At each nodal point the detailed procedure for assigning frequencies is given below, illustrated by examples using Appendices D.4 and D.5:

a. Receive frequencies are assigned to all trunk links connecting to the nodal point and, as a general rule, these must all be drawn from one of the frequency groups available (e.g. Groups I, II or III in Appendix D.4).

b. Determine the numbers of each link type connecting to the nodal point and then select a frequency group (Appendix D.4) from which all the frequencies may be drawn. Assign these frequencies to the appropriate links and record the assignment by placing a ring around each one and enter some indication of where each was used. For this purpose it is convenient (particularly for frequency repetition purposes later on) to superimpose 10-km columns on the network diagram and identify each column by a number. An example of

this assignment process follows. Appendix D.5 shows a communication network diagram with numbered columns superimposed and with letters A, B and M assigned to nodal points. Available frequencies are grouped as shown in Appendix D.4 which will be used for assigning frequencies to the network and for recording the assignments. Beginning at the forward edge of the operational area with Nodal Point No. 1, it will be seen that there are two links, one type M to A and one type B to A. All three groups (Appendix D.4) have suitable free frequencies; Group II is selected and frequencies appropriate to the link type are assigned. The frequencies are ringed to serve as a record of assignment and the column number 1 is entered above the ringed frequencies to indicate the location of the assignment on the network diagram. This completes the assignment at Nodal Point 1. At Nodal Point 2 there are two links type A to M, and one B to M. Group I is selected and frequencies are assigned to all three links according to their type. The frequencies are ringed and the column number 2 entered; and so on for the remaining nodal points. Note that although receive frequencies only are assigned at nodal points, these automatically determine the transmit frequencies at the distant end of the respective links.

c. In a large network the stage will be reached when insufficient free frequencies are available in any one group to satisfy all the requirements at a nodal point. At this stage it is permissible to assign some free frequencies from one group and some from another, provided that the required separation between all the frequencies selected is maintained. Failing this, it will be necessary to re-assign, from one group, frequencies used the farthest distance away (these can readily be identified by the column number entered at the time of assignment (see Sub-Paragraph b above), and in such circumstances that mutual interference appears to be unlikely. Compatible spare frequencies may be used but this should seldom be necessary for an initial assignment; it is better to keep the majority in reserve to overcome unpredicted interference and for use in redeployments. Before assigning a spare frequency, it is essential to check that it is compatible with all other receive and transmit frequencies which will be in use at both of the nodal points affected.

D.11. When two nodal points are connected by more than one link, no change in the assignment procedure described above is necessary. For example, two Nodal Points A and B are connected by two links, at Nodal Point A receive frequencies are assigned to both links from any one frequency group for link types B to A, and similarly at Nodal Point B for link types A to B. The compatibility of frequencies thus assigned is invariably assured.

D.12. Redeployment of a nodal point entails recovering all frequencies previously assigned to both ends of all links connecting

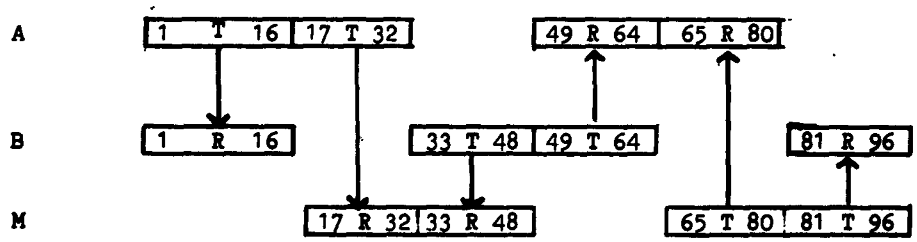
to it; modifying the network diagram; assigning a suitable letter A, B or M to the nodal point in its new position; and re-assigning frequencies to both ends of the new links connecting to it.

D.13. A complete frequency change of the whole network can be accomplished by re-lettering nodal points and making a new assignment.

Appendix D.1

FREQUENCY LISTS IN A-B-M PATTERN

Frequency List Nos.	A to B	A to M	B to M	B to A	M to A	M to B
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	1	17	33	49	65	81
2	2	18	34	50	66	82
3	3	19	35	51	67	83
4	4	20	36	52	68	84
5	5	21	37	53	69	85
6	6	22	38	54	70	86
7	7	23	39	55	71	87
8	8	24	40	56	72	88
9	9	25	41	57	73	89
10	10	26	42	58	74	90
11	11	27	43	59	75	91
12	12	28	44	60	76	92
13	13	29	45	61	77	93
14	14	30	46	62	78	94
15	15	31	47	63	79	95
16	16	32	48	64	80	96



Notes:

1. For simplicity, channel numbers are shown in columns (b) to (g) instead of actual frequencies. Frequencies are assigned to the channel numbers 1 to 96 in rising frequency order.

2. This pattern assures a minimum T-R separation of 32 channel numbers on a single link and of 16 channel numbers at a nodal point.

Appendix D.2

FREQUENCY LISTS GROUPED IN MODIFIED A-B-M PATTERN
(With Four Channel Numbers Separation)

Group	Frequency List No.	A to B	A to M	B to M	B to A	M to A	M to B
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
I	1	1	17	33	49	65	81
	5	5	21	37	53	69	85
	9	9	25	41	57	73	89
	13	13	29	45	61	77	93
II	2	2	18	34	50	66	82
	6	6	22	38	54	70	86
	10	10	26	42	58	74	90
	14	14	30	46	62	78	94
III	3	3	19	35	51	67	83
	7	7	23	39	55	71	87
	11	11	27	43	59	75	91
	15	15	31	47	63	79	95
IV	4	4	20	36	52	68	84
	8	8	24	40	56	72	88
	12	12	28	44	60	76	92
	16	16	32	48	64	80	96

Notes:

1. For simplicity, channel numbers are shown in columns (c) to (h) instead of actual frequencies. Frequencies are assigned to these channel numbers in sequence 1 to 96 in rising frequency order.

2. The minimum channel spacing in any one group is 4 channel numbers. Therefore if all receive frequencies at a nodal point are selected from a single group, the minimum receiver-receiver frequency separation is inevitably 4 channel numbers. The minimum transmitter-receiver separation remains at 16 channel numbers as the frequencies channel numbers) in each list are the same as those shown in Appendix D.1. Only the order has changed.

Appendix D.3

FREQUENCY LISTS GROUPED IN MODIFIED A-B-M PATTERN
(Showing Three Channel Numbers Separation)

Group	Frequency List No.	A to B	A to M	B to M	B to A	M to A	M to B
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
I	1	1	17	33	49	65	81
	4	4	20	36	52	68	84
	7	7	23	39	55	71	87
	10	10	26	42	58	74	90
	13	13	29	45	61	77	93
	16	16	32	48	64	80	96
II	2	2	18	34	50	66	82
	5	5	21	37	53	69	85
	8	8	24	40	56	72	88
	11	11	27	43	59	75	91
	14	14	30	46	62	78	94
III	3	3	19	35	51	67	83
	6	6	22	38	54	70	86
	9	9	25	41	57	73	89
	12	12	28	44	60	76	92
	15	15	31	47	63	79	95

Notes:

1. For simplicity, channel numbers are shown in columns (c) to (h) instead of actual frequencies. Frequencies are assigned to these channel numbers in sequence 1 to 96 in rising frequency order as shown in Appendix D.4.

2. The minimum channel spacing in any one group is 3 channel numbers. Therefore, if all receive frequencies at a nodal point are selected from a single group, the minimum receiver-receiver frequency separation is inevitably 3 channel numbers. The minimum transmitter-receiver separation remains at 16 channel numbers as the frequencies (channel numbers) in each list are the same as those shown in Appendix D.1. Only the order has changed.

Appendix D.4

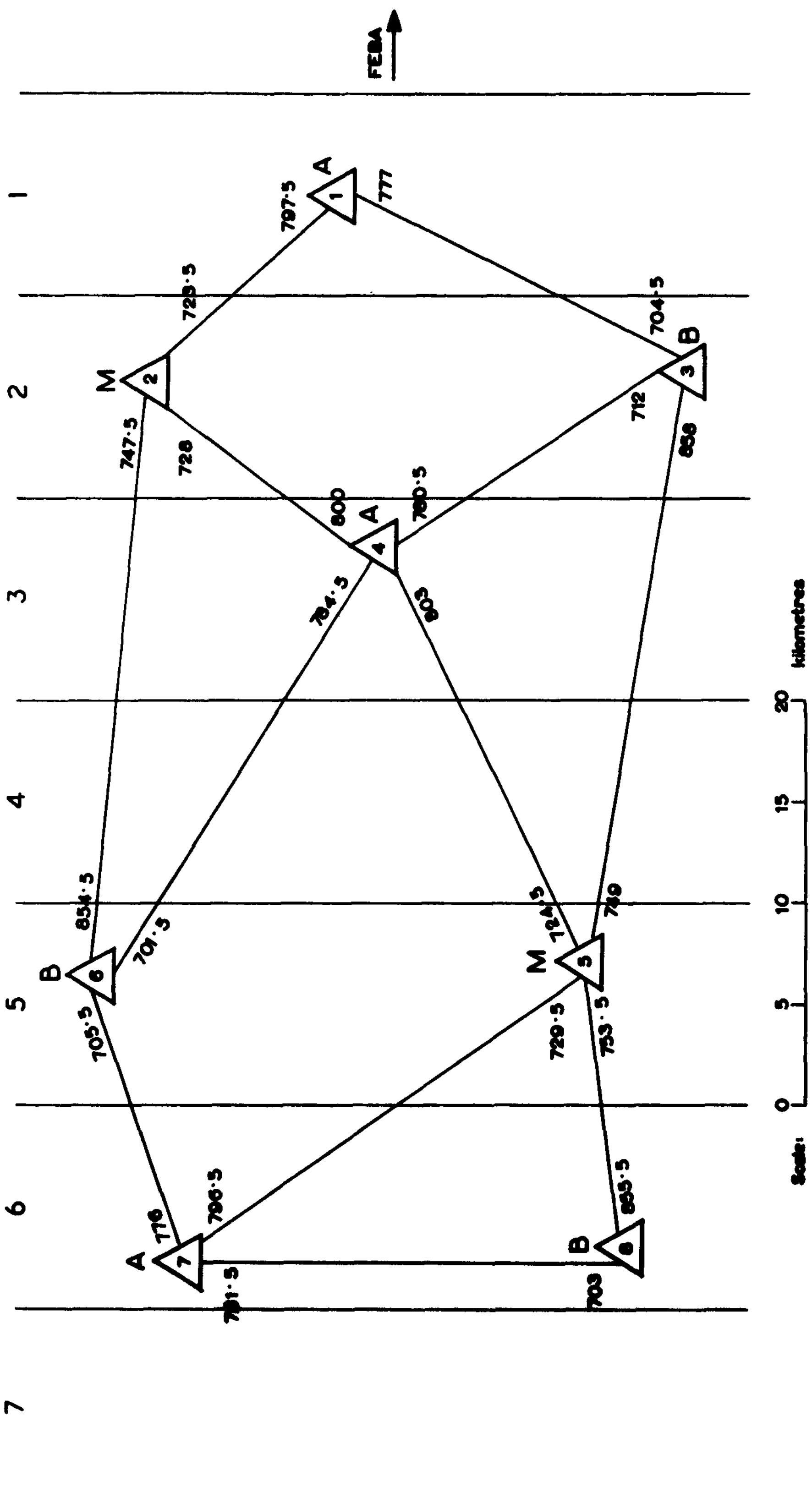
FREQUENCY LISTS IN MODIFIED A-B-M PATTERN
(Showing frequencies assigned to the channel numbers in Appendix D.3)

Group	Frequency List No.	A to B	A to M	B to M	B to A	M to A	M to B
I	1	701.5	723.5	747.5	776	796.5	854.5
	4	705.5	728	752	781.5	801	859
	7	708.5	732	758	785.5	804	873.5
	10	713.5	736	763.5	789.5	807	876.5
	13	717	741	768.5	792.5	850.5	904.5
	16	722	745.5	774	795.5	853.5	907.5
II	2	703	724.5	749	777	797.5	855.5
	5	706.5	729.5	753.5	783	802	860
	8	710	733	760	787	805	874.5
	11	714.5	737.5	765	790.5	848.5	902.5
	14	718.5	742.5	770.5	793.5	851.5	905.5
III	3	704.5	726	750.5	780.5	800	858
	6	707.5	730.5	755.5	784.5	803	861
	9	712	734.5	761	788.5	806	875.5
	12	716	739.5	767	791.5	849.5	903.5
	15	720.5	744	772	794.5	852.5	906.5

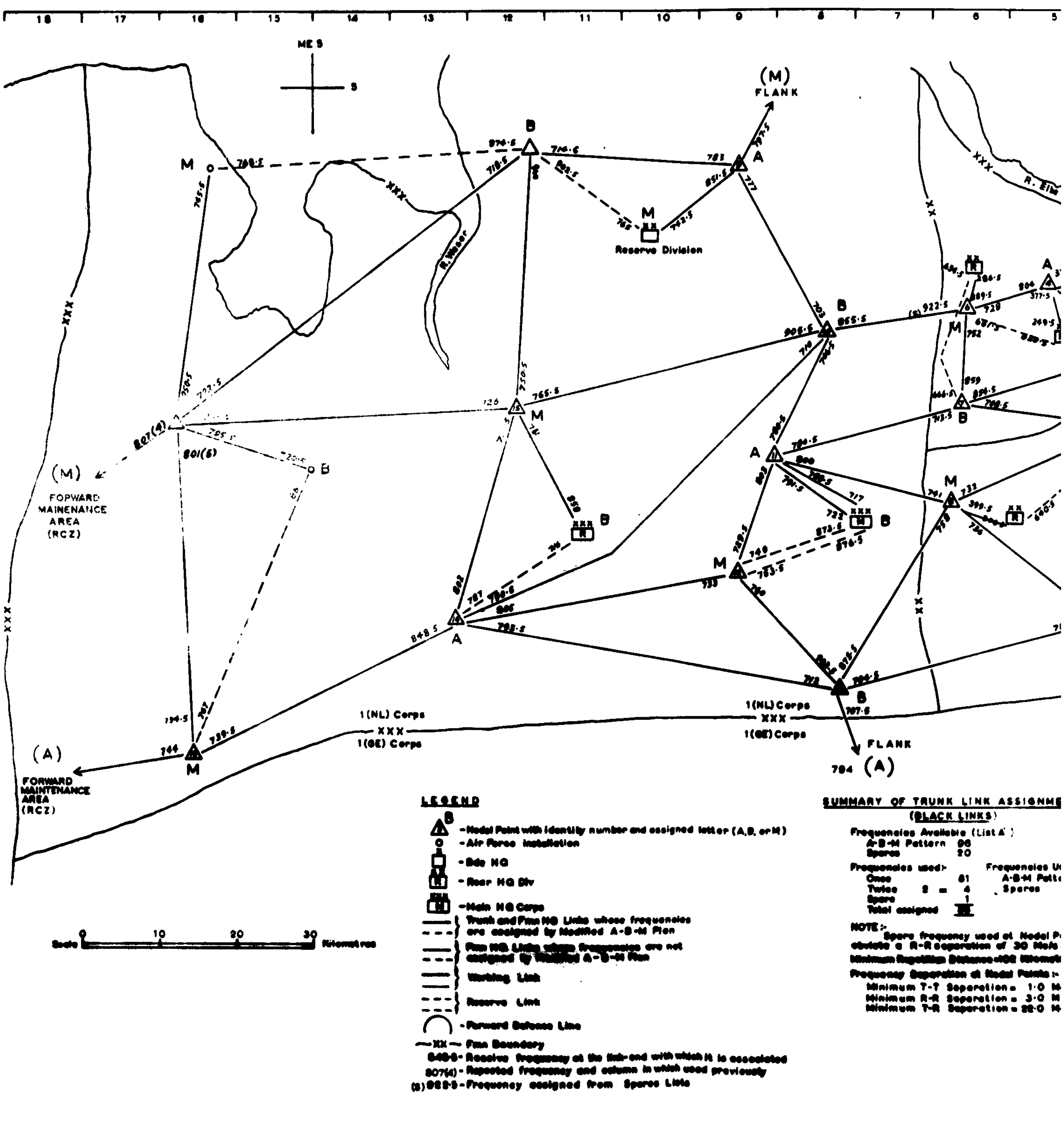
Notes: 1. The frequencies used are those allotted for trunk links in List 'A', (Table II, Page 11 refers). As the minimum separation between List 'A' frequencies is 1 Mc/s, the minimum separation in any one of the Groups I to III above is 3 Mc/s.

2. The frequencies ringed are explained in paras D8b and D9.

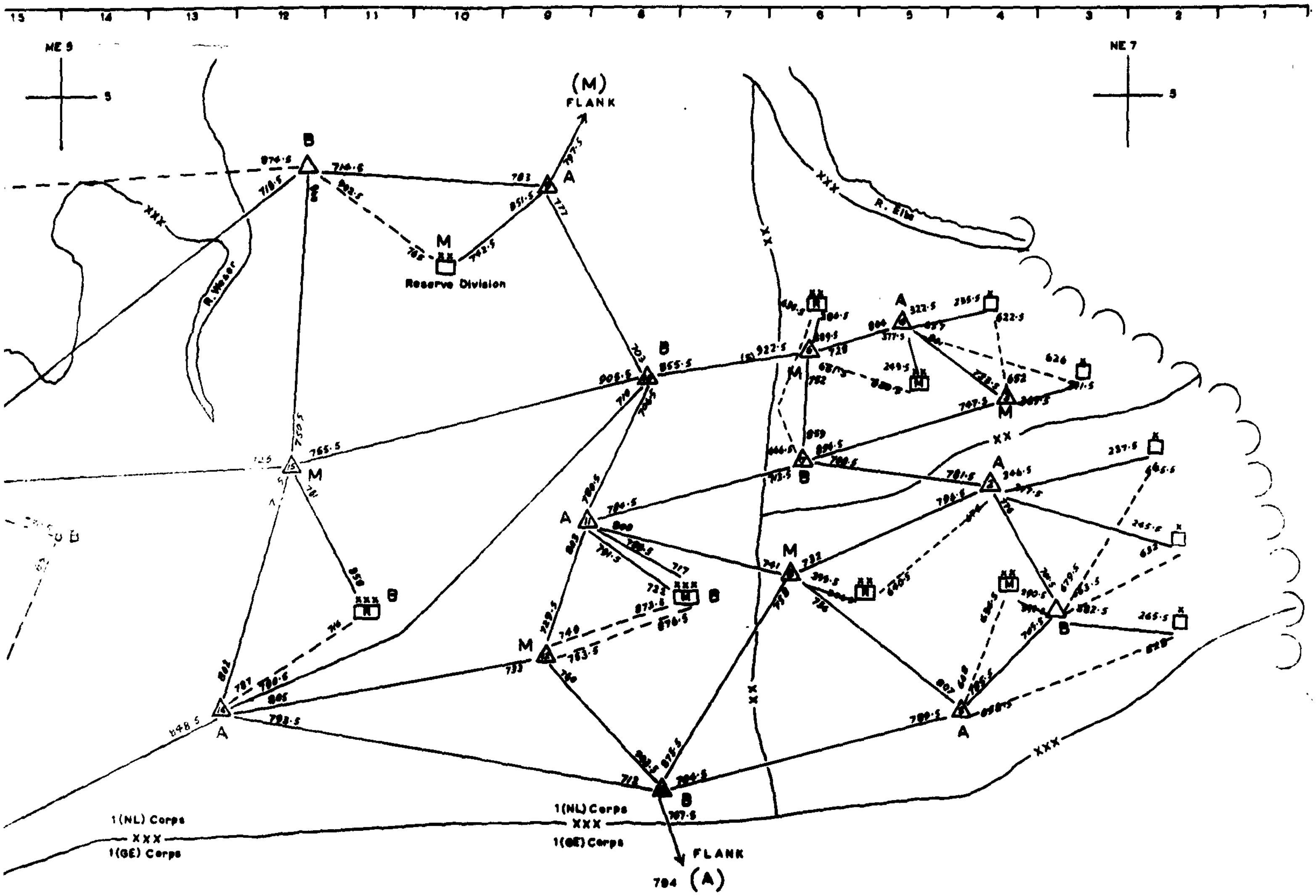
AN ASSIGNMENT OF RECEIVE FREQUENCIES
TO A COMMUNICATION NETWORK
(using Appendix D.4)



A FREQUENCY ASSIGNMENT TO I (NL) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-



A FREQUENCY ASSIGNMENT TO I (NL) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-B-M PLAN



LEGEND

- Nodal Point with identity number and assigned letter (A, B, or M)
- Air Force Installation
- Bde HQ
- Rear HQ Div
- Main HQ Corps
- Trunk and Fmn HQ Links whose frequencies are assigned by Modified A-B-M Plan
- Fmn HQ Links whose frequencies are not assigned by Modified A-B-M Plan
- Working Link
- Reserve Link
- Forward Defence Line
- —XX— Fmn Boundary
- 848·5 - Receive frequency at the link-end with which it is associated
- 807(4) - Repeated frequency and column in which used previously
- (S) 922·5 - Frequency assigned from Spares Lists

30 Kilometres

SUMMARY OF TRUNK LINK ASSIGNMENTS
(BLACK LINKS)

Frequencies Available (List A')
A-B-M Pattern 96
Spares 20

Frequencies used:-			Frequencies Unused:-	
Once		81	A-B-M Pattern	13
Twice	2 =	4	Spares	19
Spare		1		[illegible]
Total assigned		[illegible]		

NOTE:-
Spare frequency used at Nodal Point 6 to obviate a R-R separation of 30 Mc/s

Minimum Repetition Distance [illegible] Kilometres

Frequency Separation at Nodal Points:-
Minimum T-T Separation = 1·0 Mc/s
Minimum R-R Separation = 3·0 Mc/s
Minimum T-R Separation = 22·0 Mc/s

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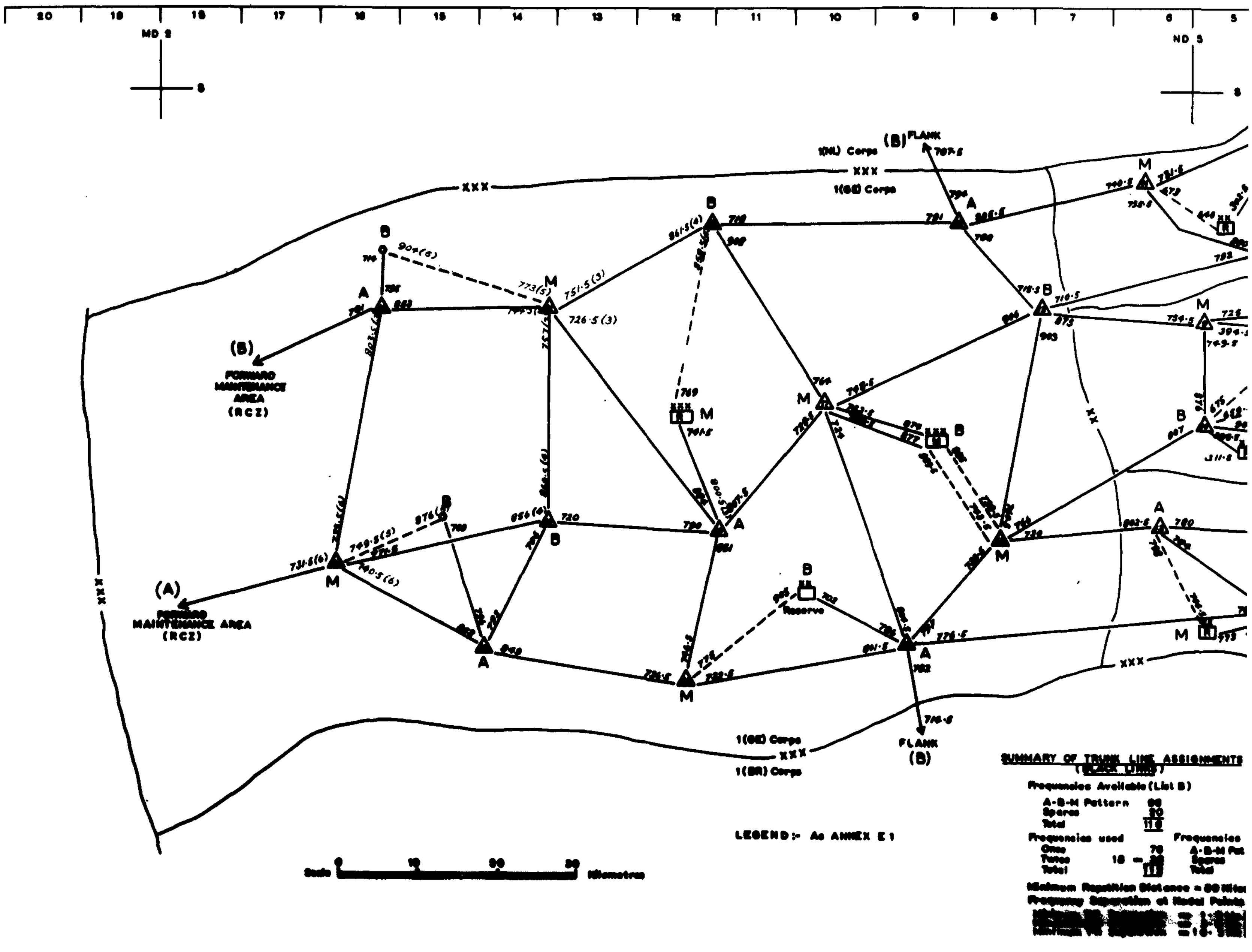
A FREQUENCY ASSIGNMENT TO I(GE) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-B-M



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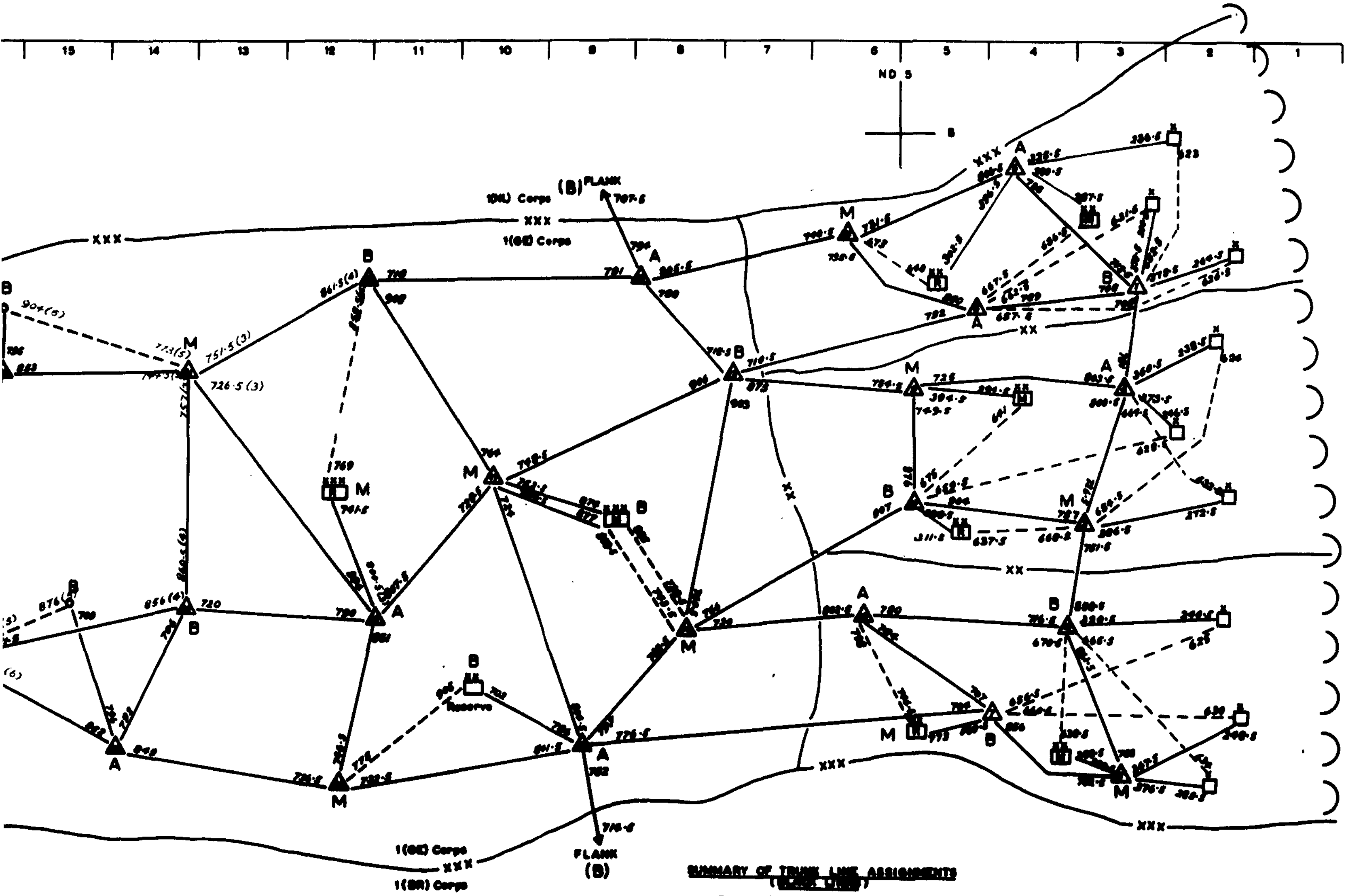
A FREQUENCY ASSIGNMENT TO I(GE) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-B-M PLAN



LEGEND:- As ANNEX E 1

10 20 30 Kilometres

SUMMARY OF TRUNK LINE ASSIGNMENTS

Frequencies Available (List B)

A-B-M Pattern
Spares
Total

Frequencies used

Frequencies Unused

A-B-M Pattern

Total

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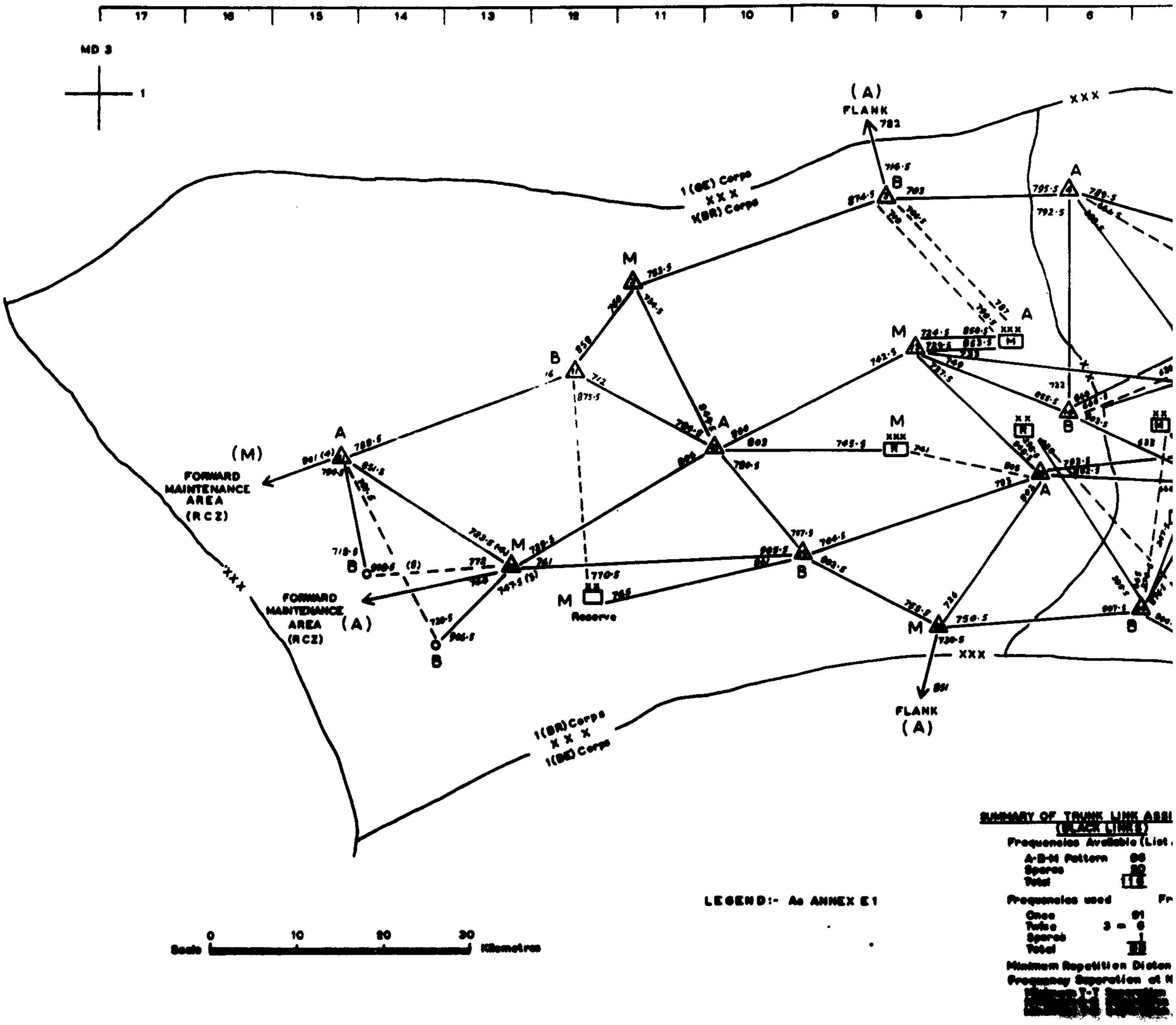
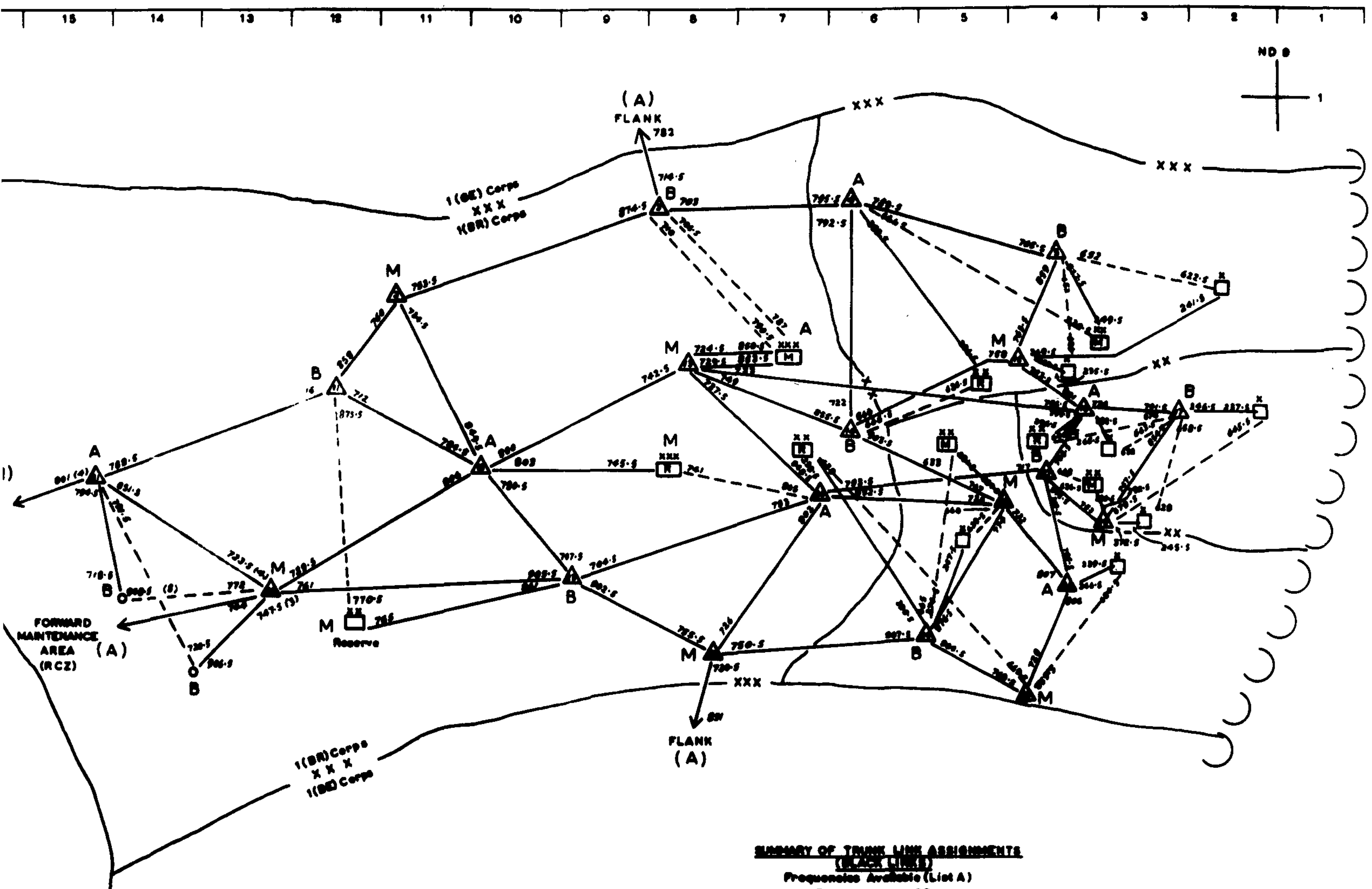
A FREQUENCY ASSIGNMENT TO I (BR) CORPS COMMUNICATION SYSTEM USING THE MODIFI



A FREQUENCY ASSIGNMENT TO I (BR) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-B-M PLAN



LEGEND:- As ANNEX E 1

10 20 30 Kilometres

SUMMARY OF TRUNK LINK ASSIGNMENTS
(BLACK LINKS)

Frequencies Available (List A)

A-B-M Pattern	96
Spares	20
Total	116

Frequencies used		Frequencies Unused	
Once	91	A B M Pattern	2
Twice	3 = 6	Spares	19
[illegible]	1	Total	21
Total	[illegible]		

Minimum Repetition Distance = 93 Kilometres

Frequency Separation at Nodal Points :-

[redacted]

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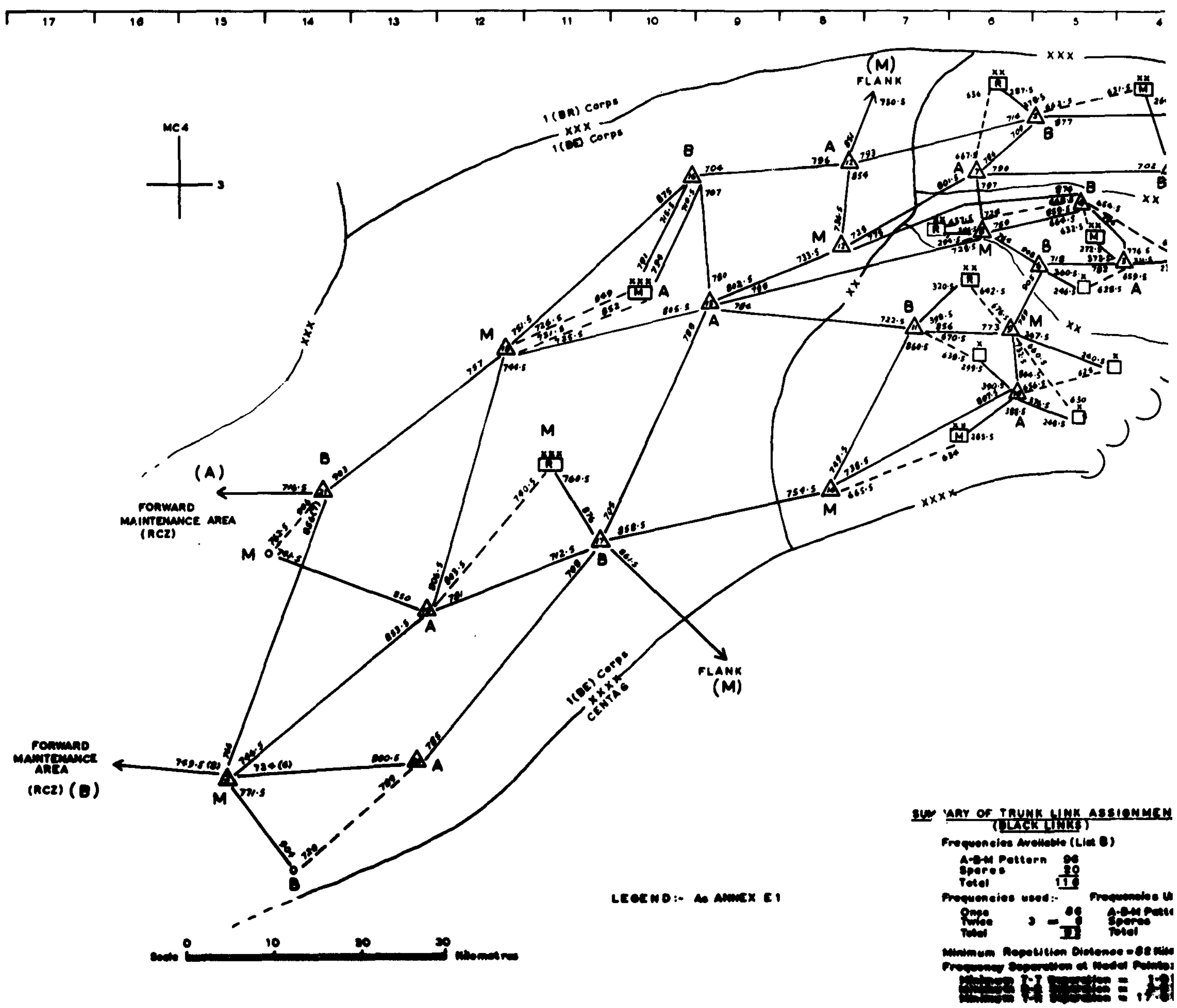
A FREQUENCY ASSIGNMENT TO I (BE) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-B-M



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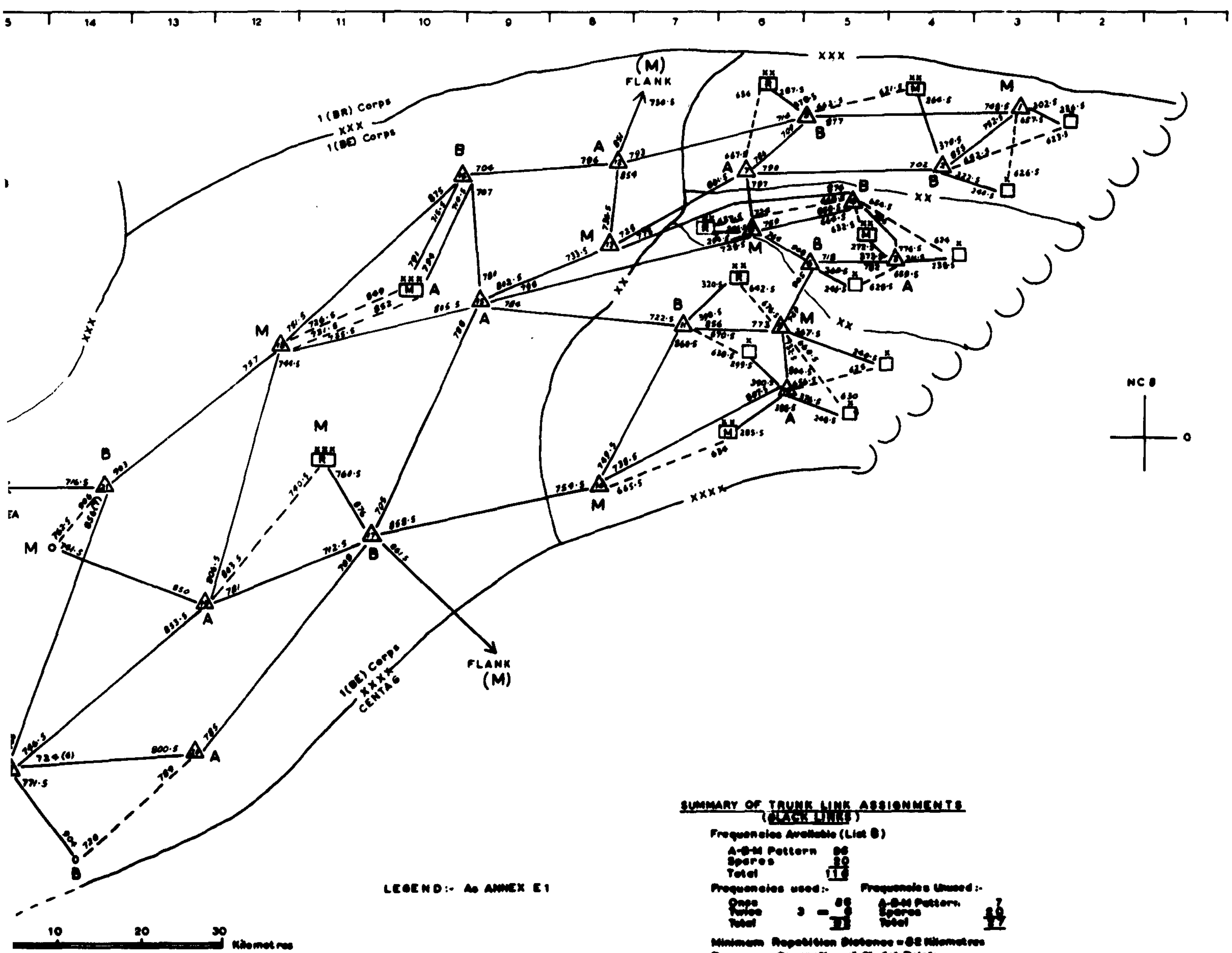
A FREQUENCY ASSIGNMENT TO I (BE) CORPS COMMUNICATION SYSTEM USING THE MODIFIED A-B-M PLAN



LEGEND:- As ANNEX E1

SUMMARY OF TRUNK LINK ASSIGNMENTS
(BLACK LINKS)

Frequencies Available (List B)

A-B-M Pattern 96
Spares 20
Total 116

Frequencies used:-
Once [illegible]
Twice 3 — [illegible]
Total [illegible]

Frequencies Unused:-
A-B-M Pattern 7
Spares 10
Total 17

Minimum Repetition Distance = 82 Kilometres

Frequency Separation at Nodal Points:-
[illegible] = 1.2 Mc/s
[illegible] = 17.0 Mc/s

ANNEX "F"

COMPARISON OF RESULTS OF FREQUENCY ASSIGNMENT METHODS

SERIAL	FEATURE	QUADRANT PLAN (Assignment Control at Army Group)	MODIFIED QUADRANT PLAN (Assignment Control at Corps)	MOD (Assign
(a)	(b)	(c)	(d)	
1	Frequency Separation	Compatibility Rules broadly met	As column (c)	A
2	Frequency Repetition Distance	a. Decentralised Assignment - 10 kms b. Central Assignment - 60 kms	a. 60 kms within Corps area b. 80 kms laterally	80 km
3	Tactical Deployments	Frequency of moves, particularly of fmn headquarters, precludes central assignment at Army Group level. The needs of only a single Corps are unlikely to be satisfied within a reasonable time.	a. Normal day-to-day moves are readily dealt with. b. Major redeployment involving re-assignment to whole network are likely to embarrass the frequency assigner owing to time factor (see Serial 5c)	The requir any scale
4	Cross-Linking and Expansion of Networks	Present minor problems which are easily solved	As column (c)	A
5	Assignment Time			
	a. Initial Deployment (excl preparation time).	$3\frac{1}{2}$ - 4 hours for each Corps. 14 - 16 hours for a 4-Corps Army Group (assignments to Corps are consecutive).	2 - $2\frac{1}{2}$ hours per Corps. Corps assignments may be made concurrently.	$\frac{1}{2}$ hour per may be mad
	b. Minor Re-deployments (incl preparation time).	Up to $1\frac{1}{2}$ hours per Corps.	Up to $\frac{1}{4}$ hour per Corps.	Up to 5 mi
	c. Major Re-deployments (incl preparation time).	Up to 5 hours for each Corps.	Up to $3\frac{1}{2}$ hours per Corps.	Up to $\frac{3}{4}$ hou
6	General	a. Due to Serial 3, central assignment at Army Group is impracticable b. Due to Serial 2a, assignment below Army Group level is also impracticable	Fmn HQ link frequencies are all compatible with trunk link frequencies and assigned separately. This permits Fmn HQ to link into any nodal point in the system without disturbing existing frequency assignments.	a. As colu b. Gives c receive separat c. Nodal p to eigh d. Extreme require

ANNEX "F"

COMPARISON OF RESULTS OF FREQUENCY ASSIGNMENT METHODS

	QUADRANT PLAN (Assignment Control at Army Group)	MODIFIED QUADRANT PLAN (Assignment Control at Corps)	MODIFIED A-B-M PLAN (Assignment Control at Corps)
	(c)	(d)	(e)
ion	Compatibility Rules broadly met	As column (c)	As column (c)
ion	a. Decentralised Assignment - 10 kms b. Central Assignment - 60 kms	a. 60 kms within Corps area b. 80 kms laterally	80 kms in all directions
nts	Frequency of moves, particularly of fmn headquarters, precludes central assignment at Army Group level. The needs of only a single Corps are unlikely to be satisfied within a reasonable time.	a. Normal day-to-day moves are readily dealt with. b. Major redeployment involving re-assignment to whole network are likely to embarrass the frequency assigner owing to time factor (see Serial 5c)	The requirements of redeployments on any scale can be readily satisfied.
orks	Present minor problems which are easily solved	As column (c)	As column (c)
tion	$3\frac{1}{2}$ - 4 hours for each Corps. 14 - 16 hours for a 4-Corps Army Group (assignments to Corps are consecutive).	2 - $2\frac{1}{2}$ hours per Corps. Corps assignments may be made concurrently.	$\frac{1}{2}$ hour per Corps. Corps assignments may be made concurrently.
tion	Up to $1\frac{1}{2}$ hours per Corps.	Up to $\frac{1}{4}$ hour per Corps.	Up to 5 minutes per Corps.
tion	Up to 5 hours for each Corps.	Up to $3\frac{1}{2}$ hours per Corps.	Up to $\frac{3}{4}$ hour per Corps.
	a. Due to Serial 3, central assignment at Army Group is impracticable b. Due to Serial 2a, assignment below Army Group level is also impracticable	Fmn HQ link frequencies are all compatible with trunk link frequencies and assigned separately. This permits Fmn HQ to link into any nodal point in the system without disturbing existing frequency assignments.	a. As column (d) this Serial b. Gives choice of values for receiver-receiver frequency separation c. Nodal points are not restricted to eight links d. Extremely simple to operate and requires minimum preparation.

2

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"Frequency Assignment to Radio Relay Area Communication Systems in the Forward Combat Zone of an Army Group"

ABSTRACT

This paper discusses the relative merits of several manual methods of frequency assignment when applied to area communication systems of the type proposed in the UK HOBART plan. A method is evolved which enables frequencies to be assigned in the band 225-960 Mc/s which are currently allotted to the military for use in war.

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